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# STRATIGRAPHIC SECTIONS OF THE PHOSPHORIA FORMATION IN WYOMING, 1947-48

By V. E. McKelvey, L. E. Smith, R. A. Hoppin, and F. C. Armstrong

UNITED STATES DEPARTMENT OF THE INTERIOR  
Douglas McKay, Secretary

GEOLOGICAL SURVEY  
W. E. Wrather, Director

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GEOLOGICAL SURVEY CIRCULAR 210

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IN WYOMING, 1947-48

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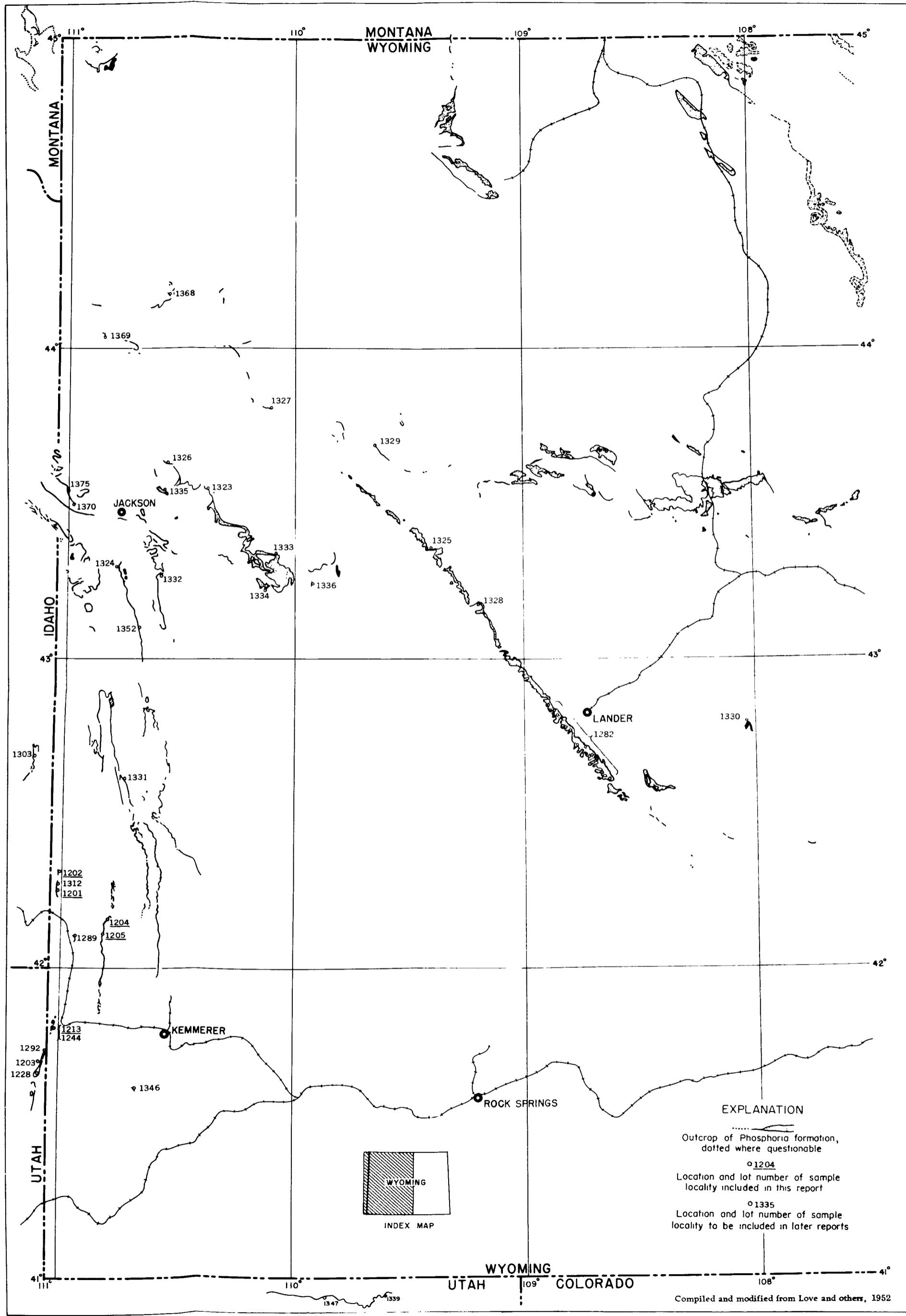
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PHOSPHORIA FORMATION OUTCROPS IN WYOMING AND LOCALITIES SAMPLED FOR PHOSPHATE

# STRATIGRAPHIC SECTIONS OF THE PHOSPHORIA FORMATION IN WYOMING, 1947-48

## INTRODUCTION

As part of a comprehensive investigation of the phosphate deposits of the western field begun in 1947, the U. S. Geological Survey has measured and sampled the Permian Phosphoria formation at many localities in Wyoming and adjacent states. Because these data will not be fully synthesized for many years, segments of the data, accompanied by little or no interpretation, will be published as preliminary reports as they are assembled. This report, which contains abstracts of some of the sections measured in western Wyoming (pl. 1), is one of this series. The field and laboratory procedures adopted in these investigations are described rather fully in a companion report (McKelvey and others, 1952a).

Many people have taken part in this investigation. R. M. Campbell, R. A. Gulbrandsen, R. A. Harris, D. M. Larrabee, F. W. O'Malley, O. A. Payne, R. S. Sears, R. P. Sheldon, and R. A. Smart participated in the description of the strata and the collection of the samples referred to in this report. D. B. Dimick, H. A. Larsen, and T. K. Rigby assisted in the preparation of exposures and the crushing and splitting of samples in the field. The laboratory preparation of samples for chemical analysis was done in Denver, Colo., under the direction of W. P. Haleatt.

Most of the  $P_2O_5$  and acid-insoluble analyses were made for the Survey by the U. S. Bureau of Mines at the Northwest Electrodevelopment Laboratory, Albany, Oreg., under the direction of S. M. Shelton and M. L. Wright. Most of the  $Al_2O_3$ ,  $Fe_2O_3$ , and loss-on-ignition analyses were made by the Trace Elements Section laboratory of the Survey in Washington, D. C., under the direction of J. C. Rabbit by chemists L. Barlow, A. Cammerer, J. Greene, F. S. Grimaldi, N. Guttag, H. Levine, H. Melo, Jr., and R. G. Milky, and most of the spectrographic reports were prepared in this laboratory by C. L. Waring. The samples from one locality (Coal Canyon) were analyzed for  $P_2O_5$ ,  $Al_2O_3$ ,  $Fe_2O_3$ ,  $V_2O_5$ , F, loss on ignition, and acid insoluble in the Chemical Laboratory of the Tennessee Valley Authority at Wilson Dam, Alabama, and spectrographically by D. M. Mortimer, of the Bureau of Mines at Albany.

Compilation of the data has been largely by R. P. Sheldon and F. D. Frieske under the supervision of R. W. Swanson. Organization of the tabular data has been largely by Anita Cozzetto.

## Acknowledgments

Special thanks are due W. W. Rubey, Helmuth Wedow, and J. Steele Williams, who contributed much in the way of advice and suggestions in planning and organization of the field program. The cost of both the field and laboratory investigations has been borne partly by the Division of Raw Materials of the Atomic Energy Commission. This support is gratefully acknowledged.

Many local residents, property owners, and phosphate companies furnished information and services and gave access to property. D. L. King of the San Francisco Chemical Company has been especially helpful in this regard.

## STRATIGRAPHY OF THE PHOSPHORIA FORMATION IN SOUTHWESTERN WYOMING

The Phosphoria formation in southwestern Wyoming consists of a lower phosphatic shale member, 95 to 145 feet in thickness, overlain by the Rex chert member, cherty limestone 65 to 145 feet in thickness, and capped by an upper shale member, 15 to 60 feet in thickness. It overlies the Pennsylvanian Wells formation and underlies the Triassic Dinwoody formation. Although the Wells formation consists largely of quartzose sandstone, calcareous in part, the upper 25 feet or more is dark gray limestone. It is equivalent to the upper member of the Wells formation in Idaho and may be the correlative of the lowermost member (A member) of the Phosphoria formation in Montana and northwestern Wyoming and the lower limestone member of the Park City formation in Utah (McKelvey, 1949). The Dinwoody formation consists of limestone, calcareous siltstone, and sandstone.

Most of the phosphatic layers are in the lower phosphatic shale member of the Phosphoria formation, but the upper shale member contains thin layers of phosphatic chert. The full thickness of the formation has been measured and sampled at Layland Canyon, Coal Canyon, and Middle Fork of Pine Creek. The phosphatic shale member contains many layers which persist, particularly in a north-south direction, over wide areas, but they may be grouped as shown in figure 1.

The correlation of the beds of the phosphatic shale member with those in adjacent parts of Idaho and Utah has already been discussed in preliminary fashion (McKelvey and others, 1952a and b) and will be considered more fully later. Suffice it to say here that whereas many of the layers throughout this member in western Wyoming may be identified in northern Utah, their identification in Idaho is uncertain except in the upper part of the member.

## STRATIGRAPHIC SECTIONS

Analytical data and abstracts of stratigraphic sections measured at five localities follow. Their locations, as well as the locations of others to be reported later, are shown in plate 1.

The semiquantitative spectrographic analyses made in the laboratories of both the Geological Survey and the Bureau of Mines are based upon comparisons with a standard plate representing known quantities of the elements tested for and made at the same exposure. Greater sensitivities for many elements can be obtained

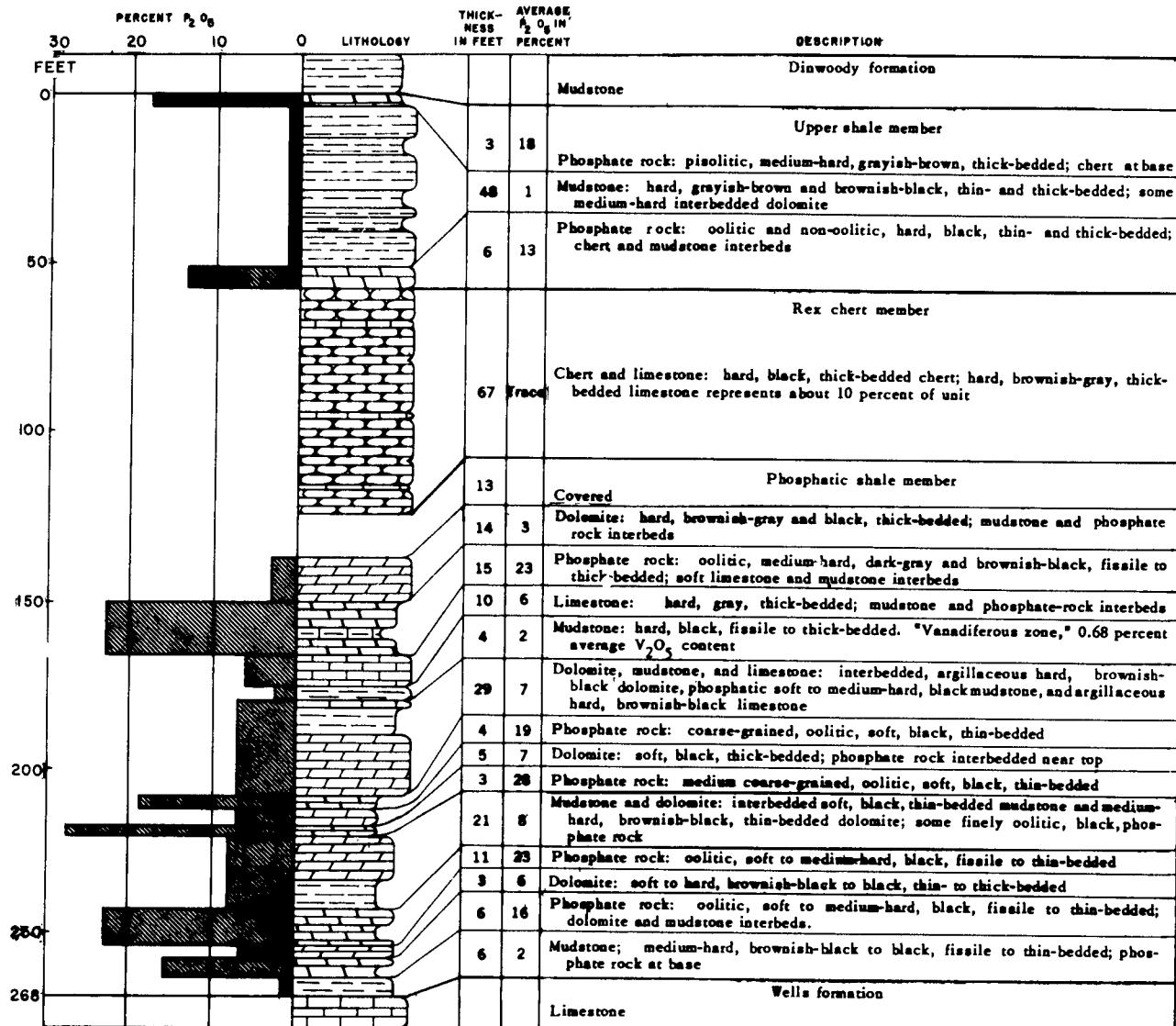


Figure 1.--Generalized section of the Phosphoria formation at Coal Canyon

by additional exposures. The standard sensitivities for the elements noted in this report are as follows:

| Element | Percent           |                 |
|---------|-------------------|-----------------|
|         | Geological Survey | Bureau of Mines |
| Al      | 0.0001            | 0.005           |
| Sb      | .001              | .05             |
| As      | .1                | .1              |
| Ba      | .001              | .08             |
| Be      | .001              | .001            |
| Bi      | .001              | .002            |
| B       | .001              | .001            |
| Cd      | .01               | .1              |
| Cs      | 1.0               | --              |
| Ca      | .001              | .01             |
| Ce      | .1                | --              |
| Cr      | .001              | .02             |
| Co      | .001              | .01             |
| Cb      | .01               | .01             |
| Cu      | .0001             | .001            |
| Dy      | .01               | --              |
| Er      | .01               | --              |
| F       | .1*               | --              |
| Gd      | .01               | --              |
| Ga      | .01               | .05             |
| Ge      | .001              | .01             |
| Au      | --                | .01             |
| Hf      | .1                | --              |
| In      | .001              | .05             |
| Fe      | .001              | .005            |
| La      | .01               | --              |
| Pb      | .01               | .1              |
| Li      | .1                | .2              |
| Mg      | .0001             | .001            |
| Mn      | .001              | .004            |
| Hg      | .1                | .1              |
| Mo      | .001              | .004            |
| Na      | .01               | --              |
| Ni      | .001              | .01             |
| P       | .1                | --              |
| Pt      | .01               | --              |
| K       | .1                | --              |
| Pr      | .01               | --              |
| Re      | .1                | --              |
| Rb      | 10.0              | --              |
| Sm      | .1                | --              |
| Sc      | .1                | --              |
| Si      | .0001             | .002            |
| Ag      | .001              | .001            |
| Na      | .1                | .05             |
| Sr      | .01               | .1              |
| Ta      | .1                | 1.0             |
| Tb      | .1                | --              |
| Tl      | .1                | --              |
| Th      | .1                | --              |
| Sn      | .01               | .01             |
| Ti      | .001              | .002            |
| W       | .1                | .1              |
| U       | .1                | --              |
| V       | .01               | .01             |
| Y       | .001              | --              |
| Zn      | .001              | .05             |
| Zr      | .001              | .003            |

\* A third exposure is required.

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LAYLAND CANYON, WYOMING. LOT NO. 1202.

Phosphatic shale member of Phosphoria formation sampled and upper shale member measured in hand trenches in Layland Canyon, sec. 19, and in next canyon to south, sec. 30, T. 27 N., R. 119 W., Lincoln County, Wyoming, on east limb of anticline. Beds P-1 through P-82 sampled in trench in lower shale member 300 feet above canyon bottom on north side of Layland Canyon; beds P-83 through R-1 sampled and upper shale member measured in trench 25 feet above canyon bottom on north side of canyon  $\frac{1}{4}$  mile to south. Beds in north trench strike N. 20° W. and dip 34° E. at Wells contact and strike N. 15° W. and dip 76° E. in upper part of section; beds in south trench strike N. 13° W. and dip 80° E. Phosphatic shale member measured by D. M. Larrabee, R. A. Hoppin, and L. E. Smith and sampled by R. P. Sheldon, R. S. Sears, and O. A. Payne in June and July 1947. Upper shale member measured by F. C. Armstrong in September 1947. Samples analyzed for  $P_2O_5$  and acid insoluble by U. S. Bureau of Mines Laboratory, Albany, Oregon, and for other constituents by Trace Elements Section Laboratory, U.S. Geological Survey, Washington, D. C.

| Bed no.  | Rock description   | Sample no.  | Thickness (feet) | Chemical analyses (percent) |           |           |                  | Cumulative thickness (feet) | Thickness x percent $P_2O_5$ (cumulative) |
|--|--|-------------|------------------|-----------------------------|-----------|-----------|------------------|-----------------------------|---|
|  |  |             |                  | $P_2O_5$                    | $Al_2O_3$ | $Fe_2O_3$ | Loss on ignition |                             |   |
| Dinwoody formation—basal bed only                            |  |             |                  |                             |           |           |                  |                             |   |
| Td-1   | Limestone, sandy   | --          | 2.0              | --                          | --        | --        | --               | 2.0                         | --  |
| Upper shale member of Phosphoria formation                   |  |             |                  |                             |           |           |                  |                             |   |
| U- 12  | Mudstone   | --          | 0.7              | --                          | --        | --        | --               | 0.7                         | --  |
| U- 11  | Mudstone, contains phosphatic limestone concretion at base | --          | 0.8              | --                          | --        | --        | --               | 1.5                         | --  |
| U- 10  | Mudstone, calcareous, cherty                               | --          | 1.0              | --                          | --        | --        | --               | 2.5                         | --  |
| U- 9   | Mudstone   | --          | 3.2              | --                          | --        | --        | --               | 5.7                         | --  |
| U- 8   | Mudstone   | --          | 2.2              | --                          | --        | --        | --               | 7.9                         | --  |
| U- 7   | Mudstone   | --          | 1.1              | --                          | --        | --        | --               | 9.0                         | --  |
| U- 6   | Mudstone, calcareous                                       | --          | 0.75             | --                          | --        | --        | --               | 9.75                        | --  |
| U- 5   | Mudstone   | --          | 1.4              | --                          | --        | --        | --               | 11.15                       | --  |
| U- 4   | Mudstone   | --          | 0.35             | --                          | --        | --        | --               | 11.50                       | --  |
| U- 3   | Limestone, sandy   | --          | 0.4              | --                          | --        | --        | --               | 11.90                       | --  |
| U- 2   | Phosphate rock, cherty                                     | --          | 1.1              | --                          | --        | --        | --               | 13.00                       | --  |
| U- 1   | Phosphate rock, cherty                                     | --          | 1.5              | --                          | --        | --        | --               | 14.50                       | --  |
| Rex chert member of the Phosphoria formation—basal beds only |  |             |                  |                             |           |           |                  |                             |   |
| R- 1   | Chert, contains calcite veinlets                           | RAH- 147-47 | 10.0             | 0.7                         | --        | --        | --               | 73.3                        | 10.0                                      |
| Phosphatic shale member of Phosphoria formation              |  |             |                  |                             |           |           |                  |                             |   |
| P-105  | Limestone, argillaceous                                    | RAH- 148-47 | 6.0              | 1.7                         | --        | --        | --               | 33.5                        | 6.0                                       |
| P-104  | Phosphate rock   | RAH- 149-47 | 0.3              | 24.0                        | --        | --        | --               | 19.4                        | 6.3                                       |
| P-103  | Mudstone, contains phosphatic mudstone lens 0.2 foot thick | RAH- 150-47 | 1.0              | 4.9                         | --        | --        | --               | 67.9                        | 7.3                                       |
| P-102  | Mudstone   | RAH- 151-47 | 0.6              | 1.2                         | --        | --        | --               | 75.3                        | 7.9                                       |
| P-101  | Mudstone, calcareous                                       | RAH- 152-47 | 2.6              | 0.5                         | --        | --        | --               | 49.5                        | 10.5                                      |
| P-100  | Mudstone   | RAH- 153-47 | 1.8              | 4.2                         | --        | --        | --               | 70.2                        | 12.3                                      |

| Bed no. | Rock description  | Sample no. | Thickness (feet) | Chemical analyses (percent) |           |           |                  | Cumulative thickness (feet) | Thickness $\times$ percent $P_2O_5$ (cumulative) |
|---------|---|------------|------------------|-----------------------------|-----------|-----------|------------------|-----------------------------|--|
|         |   |            |                  | $P_2O_5$                    | $Al_2O_3$ | $Fe_2O_3$ | Loss on ignition |                             |  |
| P- 99   | Phosphate rock  | RAH-154-47 | 1.5              | 24.8                        | 2.4       | 4.47      | 6.8              | 18.6                        | 13.8   |
| P- 98   | Phosphate rock and mudstone                               | RAH-155-47 | 1.15             | 21.0                        | 2.8       | 4.02      | 6.4              | 31.1                        | 69.08  |
| P- 97   | Phosphate rock  | RAH-156-47 | 1.4              | 29.8                        | 1.5       | 4.48      | 6.6              | 9.5                         | 93.23  |
| P- 96   | Phosphate rock  | RAH-157-47 | 3.1              | 31.5                        | 1.1       | 3.15      | 7.5              | 4.6                         | 134.95   |
| P- 95   | Phosphate rock  | RAH-158-47 | 2.3              | 29.6                        | 1.9       | 0.79      | 8.30             | 9.9                         | 232.60   |
| P- 94   | Mudstone, phosphatic Limestone, argillaceous              | RAH-159-47 | 0.7              | 12.2                        | 6.7       | 5.74      | 7.8              | 50.1                        | 300.68   |
| P- 93   | Phosphate rock  | RAH-160-47 | 2.2              | 0.3                         | 4.5       | 4.45      | 16.8             | 40.2                        | 24.65  |
| P- 92   | Phosphate rock, mudstone, and limestone                   | RAH-161-47 | 1.1              | 29.6                        | 2.1       | 3.82      | 8.0              | 9.0                         | 309.88   |
| P- 91   | Phosphate rock  | RAH-162-47 | 1.2              | 20.6                        | 3.9       | 1.04      | 9.50             | 26.1                        | 342.44   |
| P- 90   | Phosphate rock  | RAH-163-47 | 2.3              | 28.4                        | 2.5       | 3.76      | 7.0              | 11.7                        | 367.16   |
| P- 89   | Phosphate rock, argillaceous                              | RAH-164-47 | 1.2              | 20.6                        | 5.3       | 4.24      | 6.5              | 31.5                        | 432.48   |
| P- 88   | Phosphate rock  | RAH-165-47 | 2.1              | 30.1                        | 2.4       | 4.86      | 5.1              | 11.5                        | 457.20   |
| P- 87   | Mudstone, calcareous and phosphate rock                   | RAH-166-47 | 1.0              | 9.3                         | 5.4       | 5.58      | 15.4             | 40.3                        | 520.41   |
| P- 86   | Mudstone, calcareous                                      | RAH-167-47 | 2.2              | 2.3                         | 6.9       | 4.83      | 18.2             | 51.0                        | 529.71   |
| P- 85   | Phosphate rock, calcareous and limestone                  | RAH-168-47 | 0.5              | 20.8                        | 2.5       | 4.89      | 17.6             | 33.55                       | 534.77   |
| P- 84   | Mudstone, phosphatic Lime stone, "hanging-wall limestone" | RAH-169-47 | 1.5              | 13.7                        | 9.0       | 6.22      | 13.8             | 36.3                        | 565.72   |
| P- 83   | "   | RAH-170-47 | 3.2              | 0.7                         | --        | --        | --               | 10.4                        | 567.96   |
| P- 82   | Mudstone, phosphatic                                      | LES-258-47 | 0.3              | 8.9                         | --        | --        | --               | 52.3                        | 570.63   |
| P- 81   | Mudstone  | LES-257-47 | 0.4              | 0.5                         | --        | --        | --               | 79.4                        | 570.83   |
| P- 80   | Mudstone  | LES-256-47 | 0.65             | 0.4                         | --        | --        | --               | 64.1                        | 571.09   |
| P- 79   | Mudstone  | LES-255-47 | 0.5              | 0.4                         | --        | --        | --               | 52.3                        | 571.29   |
| P- 78   | Mudstone  | LES-254-47 | 0.5              | 0.6                         | --        | --        | --               | 74.1                        | 571.59   |
| P- 77   | Mudstone  | LES-253-47 | 0.45             | 4.8                         | --        | --        | --               | 60.4                        | 573.75   |
| P- 76   | Mudstone, phosphatic                                      | LES-252-47 | 0.4              | 8.4                         | --        | --        | --               | 53.7                        | 577.11   |
| P- 75   | Limestone, argillaceous, "footwall limestone"             | LES-251-47 | 1.3              | 1.6                         | --        | --        | --               | 33.0                        | 579.19   |
| P- 74   | Mudstone  | LES-250-47 | 0.4              | 3.3                         | --        | --        | --               | 75.0                        | 580.51   |
| P- 73   | Mudstone, phosphatic                                      | LES-249-47 | 0.6              | 11.1                        | --        | --        | --               | 50.4                        | 587.17   |
| P- 72   | Mudstone, calcareous                                      | RAH-139-47 | 1.6              | 0.7                         | --        | --        | --               | 66.6                        | 588.29   |
| P- 71   | Mudstone, calcareous                                      | RAH-138-47 | 1.0              | 0.5                         | --        | --        | --               | 66.6                        | 588.79   |
| P- 70   | Limestone, argillaceous                                   | RAH-137-47 | 2.2              | 0.6                         | --        | --        | --               | 41.5                        | 590.11   |
| P- 69   | Mudstone, calcareous, phosphatic                          | RAH-136-47 | 2.9              | 12.0                        | --        | --        | --               | 35.6                        | 624.91   |
| P- 68   | Limestone, argillaceous                                   | RAH-135-47 | 0.5              | 2.5                         | --        | --        | --               | 36.3                        | 626.16   |
| P- 67   | Mudstone, phosphatic                                      | RAH-134-47 | 0.7              | 14.9                        | --        | --        | --               | 42.1                        | 636.59   |
| P- 66   | Limestone, argillaceous                                   | RAH-133-47 | 0.8              | 3.9                         | --        | --        | --               | 38.6                        | 639.71   |
| P- 65   | Phosphate rock, argillaceous                              | RAH-132-47 | 2.1              | 15.6                        | --        | --        | --               | 21.9                        | 672.47   |
| P- 64   | Limestone, argillaceous, phosphatic                       | RAH-131-47 | 0.8              | 9.7                         | --        | --        | --               | 31.4                        | 680.23   |
| P- 63   | Phosphate rock, argillaceous                              | RAH-129-47 | 3.5              | 17.1                        | --        | --        | --               | 62.55                       | 740.08   |
| --      | Three limestone concretions in bed P-63                   | RAH-130-47 | (0.0-1.4)        | 2.0                         | --        | --        | --               | 1.8                         | --   |

|       |  |             |     |      |     |      |      |      |        |          |          |
|-------|--|-------------|-----|------|-----|------|------|------|--------|----------|----------|
| P- 62 | Phosphate rock, argillaceous             | RAH- 128-47 | 0.7 | 17.6 | --  | --   | --   | --   | --     | 25.1     | 63.25    |
| P- 61 | Phosphate rock, argillaceous             | RAH- 127-47 | 1.7 | 17.5 | --  | --   | --   | --   | --     | 24.9     | 64.95    |
| P- 60 | Limestone, argillaceous                  | RAH- 126-47 | 3.0 | 1.7  | --  | --   | --   | --   | --     | 32.9     | 67.95    |
| P- 59 | Phosphate rock, argillaceous             | RAH- 125-47 | 0.7 | 19.5 | --  | --   | --   | --   | --     | 26.0     | 68.65    |
| P- 58 | Mudstone, calcareous, phosphatic         | RAH- 124-47 | 0.4 | 10.2 | --  | --   | --   | --   | --     | 45.7     | 69.05    |
| P- 57 | Phosphate rock, argillaceous, calcareous | RAH- 123-47 | 0.8 | 19.4 | --  | --   | --   | --   | --     | 25.0     | 69.85    |
| P- 56 | Phosphate rock, argillaceous             | RAH- 122-47 | 0.7 | 13.4 | --  | --   | --   | --   | --     | 33.0     | 820.50   |
| P- 55 | Limestone, phosphatic, argillaceous      | RAH- 121-47 | 2.5 | 10.5 | --  | --   | --   | --   | --     | 70.55    | 829.88   |
| P- 54 | Phosphate rock and mudstone, calcareous  | RAH- 120-47 | 1.6 | 14.9 | --  | --   | --   | --   | --     | 21.1     | 856.13   |
| P- 53 | Limestone, phosphatic                    | RAH- 119-47 | 0.4 | 15.5 | --  | --   | --   | --   | --     | 17.0     | 913.19   |
| P- 52 | Mudstone                                 | RAH- 118-47 | 0.7 | 6.6  | --  | --   | --   | --   | --     | 7.4      | 879.97   |
| P- 51 | Limestone                                | RAH- 117-47 | 0.7 | 7.4  | --  | --   | --   | --   | --     | 9.4      | 918.97   |
| P- 50 | Phosphate rock                           | RAH- 116-47 | 0.6 | 28.7 | --  | --   | --   | --   | --     | 26.0     | 886.17   |
| P- 49 | Limestone, argillaceous                  | RAH- 115-47 | 1.7 | 3.4  | --  | --   | --   | --   | --     | 15.2     | 75.05    |
| P- 48 | Phosphate rock                           | RAH- 114-47 | 3.8 | 30.1 | 2.2 | 3.30 | 8.9  | 9.0  | 82.55  | 1,033.35 |          |
| P- 47 | Limestone, argillaceous, phosphatic      | RAH- 113-47 | 2.0 | 10.4 | --  | --   | --   | --   | --     | 28.2     | 84.55    |
| P- 46 | Mudstone, phosphatic, calcareous         | RAH- 112-47 | 1.3 | 14.3 | --  | --   | --   | --   | --     | 41.7     | 85.85    |
| P- 45 | Mudstone                                 | RAH- 30-47  | 3.9 | 7.2  | --  | --   | --   | --   | --     | 51.8     | 1,072.74 |
| P- 44 | Mudstone, calcareous                     | RAH- 29-47  | 2.1 | 2.5  | --  | --   | --   | --   | --     | 46.3     | 1,100.82 |
| P- 43 | Mudstone, phosphatic, calcareous         | RAH- 28-47  | 0.6 | 12.0 | --  | --   | --   | --   | --     | 46.3     | 1,106.07 |
| P- 42 | Limestone, argillaceous                  | RAH- 27-47  | 3.1 | 6.5  | --  | --   | --   | --   | --     | 28.0     | 1,113.27 |
| P- 41 | Phosphate rock, argillaceous             | RAH- 26-47  | 0.5 | 23.0 | --  | --   | --   | --   | --     | 26.5     | 95.55    |
| P- 40 | Phosphate rock                           | RAH- 25-47  | 0.6 | 27.7 | --  | --   | --   | --   | --     | 15.7     | 1,144.92 |
| P- 39 | Mudstone, phosphatic                     | RAH- 24-47  | 1.0 | 9.7  | --  | --   | --   | --   | --     | 46.2     | 1,161.54 |
| P- 38 | Mudstone, calcareous                     | RAH- 23-47  | 1.0 | 3.3  | --  | --   | --   | --   | --     | 53.2     | 1,171.24 |
| P- 37 | Phosphate rock, argillaceous             | RAH- 22-47  | 0.4 | 17.7 | --  | --   | --   | --   | --     | 34.4     | 99.05    |
| P- 36 | Mudstone, phosphatic                     | RAH- 21-47  | 2.0 | 12.3 | --  | --   | --   | --   | --     | 50.0     | 1,181.62 |
| P- 35 | Mudstone                                 | RAH- 20-47  | 0.3 | 7.1  | --  | --   | --   | --   | --     | 61.3     | 1,206.22 |
| P- 34 | Limestone                                | RAH- 19-47  | 1.6 | 2.0  | --  | --   | --   | --   | --     | 18.6     | 1,208.35 |
| P- 33 | Phosphate rock, argillaceous             | RAH- 18-47  | 0.5 | 25.6 | 3.7 | 4.32 | 8.6  | 20.0 | 103.45 | 1,211.55 |          |
| P- 32 | Phosphate rock                           | RAH- 17-47  | 0.7 | 25.6 | 3.6 | 3.76 | 9.7  | 19.0 | 108.75 | 1,224.35 |          |
| P- 31 | Phosphate rock, argillaceous             | RAH- 16-47  | 0.2 | 18.1 | 4.5 | 4.28 | 11.3 | 34.0 | 104.15 | 1,242.27 |          |
| P- 30 | Phosphate rock, argillaceous             | RAH- 15-47  | 1.1 | 19.1 | 3.3 | 3.54 | 11.6 | 26.6 | 105.45 | 1,245.89 |          |
| P- 29 | Phosphate rock                           | RAH- 14-47  | 1.2 | 31.4 | 1.8 | 4.56 | 6.4  | 9.8  | 106.65 | 1,266.90 |          |
| P- 28 | Phosphate rock                           | RAH- 13-47  | 2.1 | 30.8 | 1.7 | 3.78 | 6.6  | 10.3 | 108.75 | 1,304.58 |          |
| P- 27 | Phosphate rock                           | RAH- 12-47  | 0.4 | 29.8 | 2.1 | 4.62 | 7.1  | 10.0 | 109.15 | 1,369.26 |          |
| P- 26 | Phosphate rock                           | RAH- 11-47  | 0.6 | 30.4 | 2.2 | 3.92 | 6.8  | 10.5 | 109.75 | 1,381.18 |          |
| P- 25 | Phosphate rock                           | RAH- 10-47  | 0.8 | 26.0 | 3.6 | 3.94 | 8.4  | 18.7 | 110.55 | 1,399.42 |          |
| P- 24 | Phosphate rock                           | RAH- 9-47   | 0.3 | 27.9 | 2.6 | 3.92 | 8.2  | 13.4 | 110.85 | 1,420.22 |          |
| P- 23 | Phosphate rock                           | RAH- 8-47   | 0.3 | 26.4 | 2.6 | 3.12 | 7.8  | 18.8 | 111.15 | 1,428.59 |          |
| P- 22 | Phosphate rock, argillaceous             | RAH- 7-47   | 0.2 | 22.1 | 2.2 | 2.88 | 7.6  | 28.4 | 111.35 | 1,436.51 |          |
| P- 21 | Phosphate rock, argillaceous             | RAH- 6-47   | 0.4 | 19.3 | 3.2 | 5.26 | 7.9  | 19.7 | 111.75 | 1,440.93 |          |
| P- 20 | Limestone, argillaceous                  | RAH- 5-47   | 1.0 | 6.4  | 4.4 | 4.54 | 23.0 | 33.3 | 112.75 | 1,448.65 |          |
| P- 19 | Mudstone, phosphatic, calcareous         | RAH- 4-47   | 0.4 | 11.9 | 6.2 | 4.80 | 12.4 | 42.3 | 113.15 | 1,455.05 |          |
|       |  |             |     |      |     |      |      |      |        |          | 1,459.81 |

| Bed no. | Rock description                              | Sample no. | Thickness (feet) | Chemical analyses (percent)   |                                |                                |                  | Cumulative thickness (feet) | Thickness <sup>x</sup> percent P <sub>2</sub> O <sub>5</sub> (cumulative) |
|---------|---|------------|------------------|-------------------------------|--------------------------------|--------------------------------|------------------|-----------------------------|---|
|         |   |            |                  | P <sub>2</sub> O <sub>5</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | Loss on ignition |                             |   |
| P- 18   | Phosphate rock, argillaceous                  | RAH-       | 3-47             | 0.7                           | 22.6                           | 4.2                            | 7.0              | 22.0                        | 113.85  |
| P- 17   | Limestone, argillaceous, phosphatic           | RAH-       | 2-47             | 1.1                           | 10.3                           | 5.5                            | 18.0             | 32.7                        | 1.475.63  |
| P- 16   | Phosphate rock, argillaceous                  | RAH-       | 1-47             | 0.4                           | 20.8                           | 6.5                            | 5.80             | 24.5                        | 1.486.96  |
| P- 15   | Dolomite, calcareous                          | DML-       | 24-47            | 1.1                           | 3.9                            | --                             | 9.4              | 13.7                        | 1.495.28  |
| P- 14   | Mudstone, cherty                              | DML-       | 23-47            | 0.1                           | 2.7                            | --                             | --               | 80.9                        | 1.499.57  |
| P- 13   | Limestone, argillaceous                       | DML-       | 22-47            | 0.7                           | 1.7                            | --                             | --               | 26.6                        | 1.499.84  |
| P- 12   | Phosphate rock                                | DML-       | 21-47            | 1.3                           | 23.9                           | --                             | --               | 19.4                        | 1.501.03  |
| P- 11   | Phosphate rock, calcareous, contains fluorite | DML-       | 20-47            | 2.3                           | 20.4                           | --                             | --               | 120.85                      | 1.532.10  |
| P- 10   | Mudstone, phosphatic                          | DML-       | 19-47            | 0.2                           | 13.8                           | --                             | --               | 42.1                        | 1.579.02  |
| P- 9    | Limestone, argillaceous                       | DML-       | 18-47            | 1.4                           | 3.2                            | --                             | --               | 23.6                        | 1.581.78  |
| P- 8    | Phosphate rock, argillaceous                  | DML-       | 17-47            | 0.1                           | 21.8                           | --                             | --               | 24.6                        | 1.586.26  |
| P- 7    | Phosphate rock, argillaceous                  | DML-       | 16-47            | 0.3                           | 25.4                           | --                             | --               | 20.1                        | 1.596.93  |
| P- 6    | Mudstone                                      | DML-       | 15-47            | 0.3                           | 2.9                            | --                             | --               | 67.0                        | 1.609.33  |
| P- 5    | Mudstone, calcareous                          | DML-       | 14-47            | 3.2                           | 0.4                            | --                             | --               | 68.6                        | 1.623.25  |
| P- 4    | Mudstone                                      | DML-       | 13-47            | 0.5                           | 0.2                            | --                             | --               | 76.2                        | 1.623.31  |
| P- 3    | Mudstone                                      | DML-       | 12-47            | 2.5                           | 0.4                            | --                             | --               | 81.0                        | 1.623.35  |
| P- 2    | Phosphate rock                                | DML-       | 11-47            | 0.3                           | 33.4                           | --                             | --               | 129.65                      | 1.623.40  |
| P- 1    | Phosphate rock                                | DML-       | 10-47            | 0.4                           | 34.8                           | --                             | --               | 130.05                      | 1.623.45  |

Wells formation—not measured

|       |                                    |    |    |    |    |    |    |    |    |
|-------|------------------------------------|----|----|----|----|----|----|----|----|
| Cw- 1 | Mudstone, calcareous and limestone | -- | -- | -- | -- | -- | -- | -- | -- |
|-------|------------------------------------|----|----|----|----|----|----|----|----|

SPECTROGRAPHIC ANALYSES—LAYLAND CANYON, WYOMING. LOT NO. 1202.

Semi-quantitative analyses of samples of the Phosphoria formation, Layland Canyon, Wyoming (see immediately preceding pages for location of section, thickness and description of strata, and chemical analyses of samples), made by U. S. Geological Survey Laboratory, Geochemistry and Petrology Branch, Washington, D. C. In addition to the elements listed in the table below, Sb, As, Be, Bi, Ce, Cs, Co, Cb, Ge, In, Hg, Nd, Pt, Re, Rb, Sc, Ta, Ti, Th, and W were looked for in all samples but were not detected.

Explanation of symbols

A = more than 10 percent      F = 0.001-0.01 percent  
 B' = 1-10 percent<sup>1</sup>      G = less than 0.001 percent  
 D = 0.1-1 percent      ND = not detected  
 E = 0.01-0.1 percent

| Bed no.                                | Sample no. | Al | Ba | B | Cd | Ca | Cr | Cu | Fe | La | Pb | Mg | Mn | Mo | Ni | P  | Si | Ag | Na | Sr | Sn | Ti | V | Y | Zn | Zr |
|--|------------|----|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|----|----|
| Beds P-105 through P-100 not analyzed. |            |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |    |    |
| P-99                                   | RAH-154-47 | B' | F  | F | F  | A  | E  | F  | B' | E  | E  | D  | E  | F  | E  | A  | B' | G  | D  | D  | F  | E  | D | E | E  |    |
| P-98                                   | RAH-155-47 | B' | E  | F | F  | A  | E  | E  | B' | E  | E  | D  | E  | F  | E  | A  | B' | G  | D  | D  | F  | E  | D | E | F  |    |
| P-97                                   | RAH-156-47 | B' | D  | F | F  | A  | E  | F  | B' | E  | E  | D  | E  | F  | E  | A  | B' | G  | D  | D  | F  | E  | D | E | F  |    |
| P-96                                   | RAH-157-47 | B' | F  | F | F  | A  | E  | E  | B' | F  | E  | D  | E  | F  | E  | A  | B' | G  | D  | D  | F  | E  | D | E | F  |    |
| P-95                                   | RAH-158-47 | B' | F  | F | E  | A  | E  | E  | B' | F  | E  | D  | E  | F  | E  | A  | B' | G  | D  | D  | F  | E  | D | E | F  |    |
| P-94                                   | RAH-159-47 | B' | E  | F | F  | B' | D  | E  | B' | E  | E  | D  | E  | F  | E  | B' | A  | G  | D  | D  | F  | D  | D | E | E  |    |
| P-93                                   | RAH-160-47 | B' | F  | F | F  | A  | D  | F  | B' | ND | F  | B' | E  | F  | D  | A  | B' | G  | D  | D  | F  | E  | D | E | E  |    |
| P-92                                   | RAH-161-47 | B' | F  | F | F  | B' | E  | D  | F  | E  | F  | D  | E  | F  | E  | F  | A  | B' | G  | D  | D  | F  | E | D | E  |    |
| P-91                                   | RAH-162-47 | B' | F  | F | F  | A  | D  | F  | B' | E  | E  | D  | E  | F  | E  | F  | E  | A  | B' | G  | D  | D  | F | E | E  |    |
| P-90                                   | RAH-163-47 | B' | F  | F | F  | A  | D  | F  | B' | E  | E  | D  | E  | F  | E  | D  | E  | A  | B' | G  | D  | D  | F | D | E  |    |
| P-89                                   | RAH-164-47 | B' | F  | F | F  | ND | A  | D  | F  | B' | E  | E  | D  | E  | F  | E  | F  | E  | A  | B' | G  | D  | D | F | D  |    |
| P-88                                   | RAH-165-47 | B' | F  | F | F  | B' | F  | F  | B' | E  | E  | D  | E  | F  | E  | F  | E  | B' | A  | G  | D  | D  | F | D | E  |    |
| P-87                                   | RAH-166-47 | B' | F  | F | F  | B' | D  | F  | B' | F  | F  | D  | E  | F  | E  | D  | E  | F  | E  | B' | G  | D  | D | F | D  |    |
| P-86                                   | RAH-167-47 | B' | F  | F | F  | B' | D  | F  | B' | F  | F  | D  | E  | F  | E  | D  | E  | F  | E  | A  | G  | D  | D | F | D  |    |
| P-85                                   | RAH-168-47 | B' | F  | F | F  | A  | D  | F  | B' | E  | E  | D  | E  | F  | E  | D  | E  | F  | E  | A  | B' | G  | D | D | F  |    |
| P-84                                   | RAH-169-47 | B' | E  | F | F  | B' | D  | E  | B' | E  | E  | D  | E  | F  | E  | D  | E  | F  | E  | A  | G  | D  | D | F | D  |    |
| Beds P-83 through P-49 not analyzed.   |            |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |    |    |
| P-48                                   | RAH-114-47 | B' | E  | F | F  | A  | E  | E  | B' | E  | E  | D  | F  | F  | E  | A  | B' | G  | D  | D  | F  | E  | D | E | F  |    |
| Beds P-47 through P-34 not analyzed.   |            |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |    |    |
| P-33                                   | RAH-18-47  | B' | F  | F | E  | A  | E  | E  | B' | F  | F  | E  | D  | F  | E  | F  | F  | E  | A  | B' | G  | D  | D | F | E  |    |
| P-32                                   | RAH-17-47  | B' | F  | F | E  | A  | E  | E  | B' | F  | F  | E  | D  | F  | E  | D  | F  | E  | A  | B' | G  | D  | D | F | E  |    |
| P-31                                   | RAH-16-47  | B' | F  | F | E  | A  | E  | E  | B' | F  | F  | E  | D  | F  | E  | D  | F  | E  | A  | B' | G  | D  | D | F | E  |    |
| P-30                                   | RAH-15-47  | B' | F  | F | E  | A  | E  | E  | B' | F  | F  | E  | D  | F  | E  | D  | F  | E  | A  | B' | G  | D  | D | F | E  |    |
| P-29                                   | RAH-14-47  | B' | E  | F | F  | B' | D  | E  | B' | E  | E  | D  | E  | F  | E  | D  | E  | F  | E  | D  | F  | E  | D | E | F  |    |

<sup>1</sup> B' is equivalent to B and C of Bureau of Mines analyses.

| Bed no. | Sample no. | Al | Ba | B | Cd | Ca | Cr | Cu | Fe | La | Pb | Mg | Mn | Mo | Ni | P | Si | Ag | Na | Sr | Sn | Tl | V | Y | An | Zr |
|---------|------------|----|----|---|----|----|----|----|----|----|----|----|----|----|----|---|----|----|----|----|----|----|---|---|----|----|
| P-28    | RAH- 13-47 | B  | F  | F | E  | A  | E  | F  | B  | F  | E  | D  | F  | F  | E  | A | B' | G  | D  | D  | F  | E  | D | E | F  | F  |
| P-27    | RAH- 12-47 | B  | E  | F | E  | A  | D  | E  | B  | F  | F  | D  | F  | F  | F  | A | B' | G  | D  | E  | F  | E  | D | F | E  | F  |
| P-26    | RAH- 11-47 | B  | E  | F | E  | A  | D  | E  | B  | F  | F  | D  | E  | F  | F  | A | B' | G  | D  | E  | F  | E  | D | F | E  | E  |
| P-25    | RAH- 10-47 | B  | E  | F | E  | A  | D  | E  | B  | F  | E  | D  | E  | E  | F  | A | B' | G  | D  | E  | F  | E  | D | F | E  | F  |
| P-24    | RAH- 9-47  | B  | E  | F | E  | A  | D  | E  | B  | F  | E  | D  | E  | E  | F  | A | B' | G  | D  | E  | F  | E  | D | F | E  | F  |
| P-23    | RAH- 8-47  | B  | E  | F | E  | A  | D  | E  | B  | ND | F  | E  | D  | E  | F  | A | B' | G  | D  | E  | F  | E  | D | F | E  | F  |
| P-22    | RAH- 7-47  | B  | E  | F | E  | A  | D  | E  | B  | F  | F  | E  | B  | E  | F  | A | B' | G  | D  | E  | F  | E  | D | F | E  | F  |
| P-21    | RAH- 6-47  | B  | E  | F | E  | A  | D  | E  | B  | F  | F  | E  | B  | E  | F  | A | B' | G  | D  | E  | F  | E  | D | F | E  | F  |
| P-20    | RAH- 5-47  | B  | E  | F | E  | A  | D  | E  | B  | ND | F  | E  | B  | E  | F  | A | B' | G  | D  | E  | F  | E  | D | F | E  | F  |
| P-19    | RAH- 4-47  | B  | E  | F | E  | A  | D  | E  | B  | F  | E  | B  | E  | F  | F  | A | B' | G  | D  | E  | F  | E  | D | F | E  | F  |
| P-18    | RAH- 3-47  | B  | E  | F | E  | A  | D  | E  | B  | F  | E  | B  | E  | F  | E  | A | B' | G  | D  | E  | F  | E  | D | F | E  | F  |
| P-17    | RAH- 2-47  | B  | E  | F | E  | A  | D  | E  | B  | F  | E  | B  | E  | F  | E  | A | B' | G  | D  | E  | F  | E  | D | F | E  | F  |
| P-16    | RAH- 1-47  | B  | E  | F | E  | A  | D  | E  | B  | F  | E  | B  | E  | F  | E  | A | B' | G  | D  | E  | F  | E  | D | F | E  | F  |

Beds P-15 through P-1 not analyzed.

## COAL CANYON, WYOMING. LOT NO. 1201.

Phosphoria formation sampled in hand trenches, mine adit, and natural exposures in Coal Canyon, sec. 7, T. 26 N., R. 119 W., Lincoln County, Wyoming, on east limb of Sublette anticline. Upper shale member sampled in trench 200 feet above canyon bottom on south side; Rex chert member in natural exposures 50 feet above canyon bottom on south side; beds P-69 to F-74 from vanadiferous zone in face of adit 50 feet above canyon bottom on north side; all other beds from trench in phosphatic shale member at bottom of canyon on south side. Beds strike north and dip 75° E. Section measured by V. E. McKelvey, D. M. Larrabee, and L. E. Smith and sampled by R. A. Gulbrandsen; samples 2058-2087 collected in June 1946, all others in June 1947. Samples analyzed by Tennessee Valley Authority.

| Bed no.                           | Rock description             | Sample no. | Thickness (feet) | Chemical analyses (percent) |           |           |          |      | Cumulative thickness (feet) | Thickness x percent $P_2O_5$ (cumulative) |
|-----------------------------------|------------------------------|------------|------------------|-----------------------------|-----------|-----------|----------|------|-----------------------------|---|
|                                   |                              |            |                  | $P_2O_5$                    | $Al_2O_3$ | $Fe_2O_3$ | $V_2O_5$ | F    |                             |   |
| Dinwoody formation—basal bed only |                              |            |                  |                             |           |           |          |      |                             |   |
| Td - 1                            | Mudstone                     |            | 1.7              | 0.13                        | 11.7      | 3.0       | 0.07     | 0.09 | 9.7                         | 74.9                                      |
|                                   |                              | VEM-97-47  |                  |                             |           |           |          |      |                             | 1.7                                       |
|                                   |                              |            |                  |                             |           |           |          |      |                             | 1.70                                      |
| U- 27                             | Phosphate rock, argillaceous | VEM-96-47  | 1.7              | 24.8                        | 4.3       | 3.4       | 0.07     | 2.5  | 4.9                         | 23.8                                      |
| U- 26                             | Phosphate rock and chert     | VEM-95-47  | 0.6              | 15.14                       | 9.1       | 4.2       | —        | 1.3  | 6.7                         | 42.16                                     |
| U- 25                             | Chert, dolomitic             | VEM-94-47  | 0.8              | 6.25                        | 3.8       | 2.2       | 0.05     | 0.68 | 15.3                        | 51.24                                     |
| U- 24                             | Mudstone and chert           | VEM-93-47  | 4.0              | 0.70                        | 5.3       | 3.2       | 0.04     | 0.13 | 4.3                         | 56.24                                     |
| U- 23                             | Mudstone, cherry             | VEM-92-47  | 1.6              | 1.65                        | 5.4       | 3.8       | 0.04     | 0.18 | 2.5                         | 59.04                                     |
| U- 22                             | Mudstone                     | VEM-91-47  | 1.6              | 2.93                        | 11.2      | 4.9       | 0.09     | 0.34 | 6.1                         | 61.68                                     |
| U- 21                             | Mudstone                     | VEM-90-47  | 3.2              | 4.60                        | 10.7      | 4.5       | 0.06     | 0.58 | 7.5                         | 66.37                                     |
| U- 20                             | Mudstone                     | VEM-89-47  | 3.0              | 4.00                        | 11.7      | 4.3       | 0.10     | 0.47 | 7.2                         | 81.09                                     |
| U- 19                             | Mudstone                     | VEM-88-47  | 2.6              | 2.00                        | 7.3       | 2.5       | 0.10     | 0.31 | 9.5                         | 93.09                                     |
| U- 18                             | Mudstone, calcareous         | VEM-87-47  | 2.6              | 0.30                        | 7.8       | 2.6       | 0.06     | 0.21 | 11.7                        | 98.29                                     |
| U- 17                             | Limestone, argillaceous      | VEM-86-47  | 1.6              | 0.5                         | 3.6       | 1.5       | 0.04     | 0.11 | 24.3                        | 99.07                                     |
| U- 16                             | Mudstone                     | VEM-85-47  | 3.5              | 1.39                        | 7.3       | 2.5       | 0.05     | 0.18 | 10.6                        | 117.60                                    |
| U- 15                             | Mudstone                     | VEM-84-47  | 3.9              | 1.01                        | 4.5       | 2.3       | 0.04     | 0.16 | 11.8                        | 104.74                                    |
| U- 14                             | Mudstone                     | VEM-83-47  | 3.7              | 0.25                        | 8.7       | 2.8       | 0.08     | 0.19 | 7.5                         | 108.69                                    |
| U- 13                             | Mudstone                     | VEM-82-47  | 3.6              | 1.21                        | 8.1       | 3.2       | 0.05     | 0.24 | 7.1                         | 109.60                                    |
| U- 12                             | Mudstone                     | VEM-81-47  | 4.3              | 0.85                        | 10.4      | 3.5       | 0.08     | 0.26 | 8.6                         | 133.96                                    |
| U- 11                             | Mudstone                     | VEM-80-47  | 1.4              | 0.60                        | 10.3      | 4.0       | 0.04     | 0.26 | 8.6                         | 142.3                                     |
| U- 10                             | Mudstone, dolomitic          | VEM-79-47  | 1.0              | 1.60                        | 6.4       | 2.9       | 0.08     | 0.1' | 14.1                        | 118.45                                    |
| U- 9                              | Mudstone                     | VEM-78-47  | 0.7              | 0.91                        | 9.8       | 4.7       | 0.05     | 0.17 | 5.8                         | 120.05                                    |
| U- 8                              | Mudstone                     | VEM-77-47  | 2.7              | 1.00                        | 10.4      | 3.9       | 0.05     | 0.22 | 4.9                         | 120.69                                    |
| U- 7                              | Mudstone                     | VEM-76-47  | 3.1              | 0.75                        | 7.5       | 3.2       | 0.05     | 0.22 | 5.2                         | 123.39                                    |
| U- 6                              | Phosphate rock, cherry       | VEM-75-47  | 2.3              | 22.5                        | 3.7       | 3.3       | 0.06     | 2.1  | 6.7                         | 125.71                                    |
| U- 5                              | Mudstone                     | VEM-74-47  | 1.4              | 4.1                         | 5.1       | 3.5       | 0.04     | 0.51 | 4.4                         | 177.46                                    |
| U- 4                              | Chert                        | VEM-73-47  | 0.6              | 0.49                        | 2.4       | 2.6       | 0.04     | 0.10 | 7.6                         | 183.20                                    |
| U- 3                              | Chert                        | VEM-72-47  | 1.1              | 4.71                        | 1.5       | 3.2       | 0.03     | 0.54 | 6.0                         | 183.50                                    |
| U- 2                              | Phosphate rock, cherry       | VEM-71-47  | 0.6              | 25.5                        | 1.4       | 2.0       | 0.04     | 2.4  | 5.5                         | 188.68                                    |
| U- 1                              | Phosphate rock, argillaceous | VEM-70-47  | 0.4              | 16.7                        | 4.4       | 2.8       | 0.11     | 2.1  | 56.6                        | 203.98                                    |
|                                   |                              |            |                  |                             |           |           |          |      | 30.6                        | 210.66                                    |
|                                   |                              |            |                  |                             |           |           |          |      | 57.2                        | 57.6                                      |

| Bed no.   | Rock description   | Sample no.        | Thickness (feet) | Chemical analyses (percent)   |                                |                                |                               |      | Cumulative thickness (feet) | Thickness x percent P <sub>2</sub> O <sub>5</sub> (cumulative) |        |
|---|--|-------------------|------------------|-------------------------------|--------------------------------|--------------------------------|-------------------------------|------|-----------------------------|--|--------|
|   |  |                   |                  | P <sub>2</sub> O <sub>5</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | V <sub>2</sub> O <sub>5</sub> | F    | Loss on ignition            | Acid insoluble   |        |
| Rex chert member of Phosphoria formation        |  |                   |                  |                               |                                |                                |                               |      |                             |  |        |
| R- 7  | Chert and limestone, represents top of VEM-68-47 resampled in upper shale trench | VEM-69-47         | (1.4)            | 0.65                          | 0.7                            | 1.8                            | --                            | 0.08 | 15.3                        | 61.5   | --     |
| R- 6  | Chert and limestone  | VEM-68-47         | 8.5              | 0.11                          | 0.2                            | 2.5                            | --                            | 0.05 | 9.6                         | 73.0   | 8.5    |
| R- 5  | Chert and limestone  | VEM-67-47         | 9.0              | 0.22                          | 0.4                            | 1.9                            | --                            | 0.03 | 10.2                        | 73.8   | 0.94   |
| R- 4  | Chert and limestone  | VEM-66-47         | 10.5             | 0.20                          | 0.5                            | 2.1                            | --                            | 0.04 | 13.1                        | 66.7   | 2.92   |
| R- 3  | Chert and limestone; fos. col. no. 47-HW-48                                      | VEM-65-47         | 9.0              | 0.23                          | 0.3                            | 2.2                            | --                            | 0.04 | 9.6                         | 72.3   | 5.02   |
| R- 2  | Chert and limestone  | VEM-64-47         | 10.4             | 0.20                          | 0.7                            | 2.3                            | --                            | 0.04 | 11.6                        | 68.5   | 7.09   |
| R- 1  | Chert and limestone; fos. col. no. 47-HW-49                                      | VEM-63-47         | 9.8              | 0.40                          | 0.8                            | 2.3                            | --                            | 0.05 | 11.2                        | 69.2   | 9.17   |
|   |  | VEM-62-47         | 9.6              | 0.25                          | 0.4                            | 1.9                            | --                            | 0.05 | 14.4                        | 63.8   | 13.09  |
|   |  |                   |                  |                               |                                |                                |                               |      |                             | 66.8   | 15.49  |
| Phosphatic shale member of Phosphoria formation |  |                   |                  |                               |                                |                                |                               |      |                             |  |        |
| --  | Covered Dolomite, calcareous, argillaceous                                       | --                | 13               | --                            | --                             | --                             | --                            | --   | --                          | --   | 13.0   |
| P-107   | Phosphate rock   | DML- 9-47         | 5.7              | 0.76                          | 2.5                            | 0.9                            | 0.04                          | 0.13 | 35.7                        | 20.0   | 18.7   |
| P-106   | Mudstone; fos. col. no. 47-HW-46   | DML- 8-47         | 0.3              | 25.45                         | 4.1                            | 1.5                            | 0.05                          | 2.5  | 6.2                         | 17.8   | 4.33   |
| P-105   | Mudstone   | DML- 7-47         | 0.4              | 3.25                          | 13.3                           | 4.0                            | 0.07                          | 0.37 | 5.9                         | 6.3  | 11.97  |
| P-104   | Mudstone   | DML- 6-47         | 0.5              | 6.15                          | 10.9                           | 3.1                            | 0.06                          | 0.59 | 6.3                         | 68.8   | 19.0   |
| P-103   | Mudstone   | DML- 5-47         | 0.5              | 4.35                          | 12.1                           | 3.4                            | 0.04                          | 0.48 | 6.3                         | 75.6   | 19.4   |
| P-102   | Mudstone, dolomitic  | DML- 4-47         | 3.2              | 0.65                          | 9.3                            | 3.0                            | 0.02                          | 0.15 | 13.7                        | 66.9   | 13.27  |
| P-101   | Mudstone   | DML- 3-47         | 1.2              | 4.51                          | 10.2                           | 3.3                            | 0.04                          | 0.52 | 7.7                         | 69.3   | 16.35  |
| P-100   | Phosphate rock; fos. col. no. 47-HW-45   | DML- 2-47         | 0.4              | 25.9                          | 3.6                            | 1.1                            | 0.04                          | 2.4  | 6.5                         | 24.8   | 20.61  |
| P- 99   | Dolomite, argillaceous; fos. col. no. 47-HW-44                                   | DML- 1-47         | 1.4              | 0.81                          | 4.3                            | 1.5                            | 0.06                          | 0.15 | 28.3                        | 35.6   | 26.02  |
| P- 98   | Phosphate rock   | 2063 <sup>2</sup> | 1.1              | 29.8                          | 1.4                            | 0.8                            | 0.07                          | 3.1  | 6.2                         | 25.2   | 36.38  |
| P- 97   | Phosphate rock   | 2062 <sup>2</sup> | 1.9              | 32.9                          | 0.9                            | 0.6                            | 0.10                          | 3.8  | 5.4                         | 70.29  |        |
| P- 96   | Phosphate rock   | 2061 <sup>2</sup> | 0.7              | 27.2                          | 2.3                            | 1.1                            | 0.23                          | 2.9  | 8.6                         | 132.80   |        |
| P- 95   | Phosphate rock   | 2060              | 0.6              | 29.8                          | 1.5                            | 0.7                            | 0.26                          | 3.1  | 8.0                         | 12.4   |        |
| P- 94   | Phosphate rock   | 2059              | 0.5              | 26.9                          | 2.1                            | 1.0                            | 0.24                          | 2.7  | 9.6                         | 30.3   |        |
| P- 93   | Phosphate rock   | 2058              | 0.8              | 32.7                          | 1.2                            | 0.5                            | 0.15                          | 3.4  | 6.9                         | 15.84  |        |
| P- 92   | Phosphate rock, argillaceous   | VEM-61-47         | 1.1              | 21.6                          | 4.2                            | 1.7                            | 0.16                          | 2.2  | 9.0                         | 58.5   |        |
| P- 91   | Mudstone, dolomitic  | VEM-60-47         | 0.4              | 3.80                          | 7.8                            | 2.6                            | 0.09                          | 0.51 | 13.5                        | 33.7   |        |
| P- 90   | Limestone, argillaceous, dolomitic   | VEM-59-47         | 1.9              | 0.20                          | 3.4                            | 2.0                            | 0.08                          | 0.12 | 26.6                        | 35.6   |        |
| P- 89   | Phosphate rock   | VEM-58-47         | 0.7              | 29.3                          | 2.0                            | 2.3                            | 0.10                          | 3.0  | 9.5                         | 10.6   |        |
| P- 88   | Phosphate rock, calcareous, contains limestone lens                              | VEM-57-47         | 0.9              | 24.09                         | 0.8                            | 0.8                            | 0.06                          | 2.6  | 15.0                        | 4.7  |        |
| P- 87   | 0.0-0.3 foot thick phosphate rock, argillaceous                                  | VEM-56-47         | 0.6              | 21.03                         | 4.4                            | 1.6                            | 0.11                          | 1.9  | 8.3                         | 29.2   | 37.2   |
|   |  |                   |                  |                               |                                |                                |                               |      |                             | 37.8   | 289.80 |

|       |   |           |      |       |      |     |      |      |      |       |       |        |
|-------|---|-----------|------|-------|------|-----|------|------|------|-------|-------|--------|
| P- 86 | Phosphate rock  | VEM-55-47 | 0.5  | 27.45 | 2.1  | 1.2 | 0.06 | 2.9  | 8.1  | 13.9  | 38.3  | 303.52 |
| P- 85 | Phosphate rock  | VEM-54-47 | 0.9  | 27.44 | 1.4  | 1.1 | 0.06 | 3.0  | 8.1  | 11.3  | 39.2  | 328.22 |
| P- 84 | Phosphate rock and phosphatic mudstone                                    | VEM-53-47 | 1.8  | 16.52 | 5.3  | 1.9 | 0.05 | 1.6  | 9.5  | 40.4  | 41.0  | 357.96 |
| P- 83 | Phosphate rock, limestone, and mudstone                                   | VEM-52-47 | 1.0  | 29.41 | 2.3  | 1.7 | 0.05 | 3.2  | 5.4  | 11.80 | 42.0  | 387.37 |
| P- 82 | Limestone, argillaceous; fos. co col. no. 47-HW-43                        | VEM-51-47 | 1.7  | 2.11  | 5.8  | 2.1 | 0.06 | 0.24 | 22.1 | 41.2  | 43.7  | 390.96 |
| P- 81 | Mudstone, calcareous and phosphate rock                                   | VEM-50-47 | 2.0  | 4.04  | 8.8  | 2.5 | 0.05 | 0.45 | 14.2 | 56.8  | 45.7  | 399.04 |
| P- 80 | Limestone, argillaceous, mudstone, and phosphate rock                     | VEM-49-47 | 1.0  | 9.90  | 6.7  | 2.3 | 0.09 | 1.1  | 16.8 | 37.0  | 46.7  | 408.94 |
| P- 79 | Mudstone, calcareous  | VEM-48-47 | 0.8  | 2.16  | 9.7  | 3.0 | 0.05 | 0.31 | 16.5 | 54.7  | 47.5  | 410.67 |
| P- 78 | Phosphate rock  | VEM-47-47 | 0.4  | 28.67 | 1.9  | 2.1 | 0.11 | 2.8  | 13.1 | 5.62  | 47.9  | 422.14 |
| P- 77 | Limestone, argillaceous, calcareous mudstone, and phosphate rock          | VEM-46-47 | 2.1  | 9.92  | 6.2  | 2.6 | 0.07 | 1.1  | 22.0 | 25.2  | 50.0  | 442.97 |
| P- 76 | Limestone, "hanging-wall limestone"; fos. col. no. 47-HW-42               | VEM-45-47 | 1.6  | 0.36  | 1.1  | 0.5 | 0.06 | 0.06 | 41.1 | 5.90  | 51.6  | 443.55 |
| P- 75 | Mudstone  | VEM-44-47 | 0.75 | 2.73  | 8.6  | 3.4 | 0.52 | 0.44 | 16.7 | 59.32 | 52.35 | 445.60 |
| P- 74 | Mudstone  | VEM-43-47 | 0.4  | 0.34  | 9.8  | 3.9 | 1.75 | 0.15 | 24.9 | 51.2  | 52.75 | 445.74 |
| P- 73 | Mudstone  | VEM-42-47 | 0.65 | 0.20  | 9.6  | 4.0 | 1.45 | 0.23 | 22.6 | 56.38 | 53.40 | 445.87 |
| P- 72 | Mudstone  | VEM-41-47 | 0.9  | 0.05  | 9.7  | 4.4 | 0.37 | 0.08 | 16.6 | 65.75 | 54.30 | 445.91 |
| P- 71 | Mudstone  | VEM-40-47 | 1.05 | 6.30  | 7.1  | 3.3 | 0.14 | 0.67 | 17.4 | 46.66 | 55.35 | 452.53 |
| P- 70 | Limestone, argillaceous, "footwall limestone"; fos. col. no. 47-HW-35     | VEM-39-47 | 1.1  | 0.80  | 2.6  | 1.2 | 0.06 | 0.10 | 30.7 | 27.6  | 56.45 | 453.41 |
| P- 69 | Mudstone, phosphatic  | VEM-38-47 | 1.5  | 8.31  | 9.2  | 3.6 | 0.08 | 0.80 | 10.3 | 57.9  | 57.95 | 465.87 |
| P- 68 | Mudstone  | VEM-37-47 | 1.4  | 0.76  | 9.3  | 2.8 | 0.08 | 0.09 | 11.4 | 73.0  | 59.35 | 466.93 |
| P- 67 | Mudstone  | VEM-36-47 | 0.5  | 6.02  | 10.3 | 3.4 | 0.06 | 0.57 | 10.2 | 65.1  | 59.85 | 469.94 |
| P- 66 | Mudstone, calcareous, dolomitic   | VEM-35-47 | 2.3  | 0.66  | 5.7  | 1.9 | 0.05 | 0.08 | 25.9 | 41.4  | 62.15 | 471.46 |
| P- 65 | Mudstone, phosphatic, and calcareous phosphatic mudstone                  | VEM-34-47 | 3.0  | 9.97  | 8.0  | 2.6 | 0.03 | 1.1  | 14.3 | 42.4  | 65.15 | 501.37 |
| P- 64 | Dolomite, argillaceous  | VEM-33-47 | 0.7  | 1.51  | 5.9  | 1.9 | 0.05 | 0.18 | 25.7 | 39.9  | 65.85 | 502.43 |
| P- 63 | Mudstone, phosphatic  | VEM-32-47 | 2.0  | 12.38 | 8.5  | 2.6 | 0.08 | 1.3  | 15.9 | 35.23 | 67.85 | 527.19 |
| P- 62 | Phosphate rock, argillaceous  | VEM-31-47 | 2.0  | 13.73 | 5.1  | 2.1 | 0.17 | 1.4  | 18.7 | 25.1  | 69.85 | 554.65 |
| P- 61 | Limestone, dolomitic  | VEM-30-47 | 3.5  | 0.69  | 4.3  | 1.4 | 0.05 | 0.09 | 33.1 | 15.00 | 73.35 | 557.07 |
| P- 60 | Dolomite, argillaceous  | VEM-29-47 | 1.1  | 2.22  | 3.6  | 1.3 | 0.05 | 0.22 | 33.7 | 23.4  | 74.45 | 559.51 |
| P- 59 | Phosphate rock, dolomitic, argillaceous, dolomite lens included in sample | VEM-28-47 | 3.0  | 14.29 | 7.1  | 2.3 | 0.08 | 1.3  | 18.2 | 26.53 | 77.45 | 602.38 |
| P- 58 | Dolomite, phosphatic  | VEM-27-47 | 1.6  | 2.10  | 2.7  | 0.7 | 0.07 | 0.22 | 40.7 | 10.47 | 79.05 | 605.74 |
| P- 57 | Mudstone, phosphatic  | VEM-26-47 | 1.6  | 13.63 | 10.5 | 3.1 | 0.05 | 1.5  | 15.2 | 38.27 | 80.65 | 627.55 |
| P- 56 | Dolomite, argillaceous  | VEM-25-47 | 1.2  | 2.24  | 2.2  | 0.7 | 0.05 | 0.27 | 40.0 | 25.48 | 81.85 | 630.24 |

<sup>1</sup> Fossil collection made by H. Wedow, Paleontology and Stratigraphy Branch, U. S. Geological Survey.

<sup>2</sup> See additional analyses of selected samples at end of chemical analyses tables.

| Bed no.   | Rock description                             | Sample no.        | Thickness (feet) | Chemical analyses (percent) |           |           |          | Loss on ignition | Acid insoluble | Cumulative thickness (feet) | Thickness $\times$ percent $P_2O_5$ (cumulative) |
|---|--|-------------------|------------------|-----------------------------|-----------|-----------|----------|------------------|----------------|-----------------------------|--|
|   |  |                   |                  | $P_2O_5$                    | $Al_2O_3$ | $Fe_2O_3$ | $V_2O_5$ |                  |                |                             |  |
| P- 55   | Phosphate rock, dolomitic                    | VEM-24-47         | 1.6              | 14.85                       | 4.3       | 1.4       | 0.21     | 1.5              | 22.4           | 15.28                       | 83.45  |
| P- 54   | Dolomite                                     | VEM-23-47         | 1.3              | 5.38                        | 1.3       | 0.9       | 0.04     | 0.56             | 35.9           | 10.8                        | 84.75  |
| P- 53   | Phosphate rock and phosphatic mudstone       | VEM-22-47         | 2.5              | 21.00                       | 4.5       | 1.7       | 0.09     | 2.1              | 18.9           | 11.68                       | 87.25  |
| P- 52   | Dolomite, phosphatic                         | VEM-21-47         | 0.7              | 8.11                        | 0.1       | 0.5       | 0.07     | 0.78             | 35.8           | 4.93                        | 87.95  |
| P- 51   | Phosphate rock                               | VEM-20-47         | 0.3              | 24.35                       | 2.8       | 1.7       | 0.08     | 2.6              | 11.9           | 16.55                       | 88.25  |
| P- 50   | Dolomite                                     | VEM-19-47         | 1.3              | 4.42                        | 3.0       | 1.1       | 0.06     | 0.47             | 34.8           | 18.02                       | 89.55  |
| Fault (strikes N. 10° W. dips 60° E.) truncates beds P-50 and P-51. |  |                   |                  |                             |           |           |          |                  |                |                             |  |
| P- 49   | Phosphate rock                               | VEM-18-47         | 0.6              | 26.01                       | 3.1       | 1.4       | 0.06     | 2.9              | 11.2           | 10.08                       | 90.15  |
| P- 48   | Dolomite                                     | VEM-17-47         | 1.1              | 4.04                        | 1.7       | 1.0       | 0.07     | 0.44             | 37.0           | 13.63                       | 91.25  |
| P- 47   | Dolomite, argillaceous                       | VEM-16-47         | 1.1              | 3.05                        | 1.7       | 0.9       | 0.09     | 0.35             | 38.7           | 12.92                       | 92.35  |
| P- 46   | Dolomite, argillaceous                       | VEM-15-47         | 1.1              | 4.85                        | 3.7       | 1.7       | 0.08     | 0.56             | 30.5           | 23.8                        | 93.45  |
| P- 45   | Phosphate rock                               | VEM-14-47         | 0.8              | 28.85                       | 1.3       | 0.9       | 0.08     | 3.3              | 11.0           | 3.46                        | 94.25  |
| P- 44   | Phosphate rock                               | LES-10-47         | 1.3              | 26.24                       | 2.3       | 1.2       | 0.25     | 2.9              | 13.6           | 10.0                        | 95.55  |
| P- 43   | Phosphate rock                               | LES-9-47          | 0.7              | 29.26                       | 1.2       | 1.0       | 0.13     | 3.2              | 8.7            | 8.9                         | 96.25  |
| P- 42   | Dolomite                                     | LES-8-47          | 2.0              | 4.41                        | 2.0       | 0.8       | 0.05     | 0.44             | 33.7           | 17.8                        | 98.25  |
| P- 41   | Mudstone, phosphatic                         | LES-7-47          | 3.8              | 10.75                       | 7.9       | 2.5       | 0.05     | 1.1              | 11.7           | 48.2                        | 102.05   |
| P- 40   | Mudstone, dolomitic                          | LES-6-47          | 3.0              | 1.55                        | 4.6       | 2.1       | 0.05     | 0.19             | 22.5           | 47.4                        | 892.91   |
| P- 39   | Mudstone, phosphatic                         | LES-5-47          | 0.6              | 12.33                       | 8.5       | 2.5       | 0.07     | 1.1              | 10.2           | 47.7                        | 105.65   |
| P- 38   | Dolomite, argillaceous                       | LES-4-47          | 1.8              | 1.90                        | 2.2       | 0.9       | 0.04     | 0.21             | 31.5           | 28.7                        | 107.45   |
| P- 37   | Dolomite, argillaceous                       | LES-3-47          | 0.6              | 4.75                        | 2.3       | 0.8       | 0.05     | 0.50             | 27.6           | 29.2                        | 108.05   |
| P- 36   | Dolomite, argillaceous                       | LES-2-47          | 0.9              | 7.08                        | 2.4       | 0.8       | 0.05     | 0.75             | 24.7           | 28.8                        | 108.95   |
| P- 35   | Phosphate rock, argillaceous                 | LES-1-47          | 0.4              | 23.34                       | 3.7       | 1.3       | 0.06     | 2.3              | 8.2            | 25.2                        | 109.35   |
| P- 34   | Phosphate rock, argillaceous                 | VEM-13-47         | 0.6              | 30.00                       | 1.8       | 0.7       | 0.09     | 3.2              | 7.6            | 9.4                         | 109.95   |
| P- 33   | Mudstone and phosphate rock, contains gypsum | 2086              | 0.8              | 8.1                         | 3.0       | 2.6       | 0.35     | 0.83             | 19.6           | 48.9                        | 110.75   |
| P- 32   | Mudstone, dolomitic                          | 2085              | 1.8              | 7.2                         | 2.2       | 2.0       | --       | 0.71             | 19.1           | 41.1                        | 112.55   |
| P- 31   | Phosphate rock, argillaceous                 | 2084              | 1.0              | 18.1                        | 2.0       | 1.8       | 0.42     | 1.8              | 11.6           | 33.3                        | 113.55   |
| P- 30   | Mudstone, phosphatic                         | 2083              | 0.9              | 8.0                         | 2.5       | 2.2       | --       | 0.84             | 13.4           | 49.5                        | 114.45   |
| P- 29   | Mudstone, dolomitic                          | 2082              | 0.8              | 6.0                         | 2.4       | 1.9       | 0.23     | 0.88             | 16.6           | 40.2                        | 115.25   |
| P- 28   | Dolomite, argillaceous                       | 2081              | 1.7              | 6.4                         | 1.3       | 1.2       | 0.18     | 0.71             | 25.7           | 25.5                        | 116.95   |
| P- 27   | Phosphate rock                               | 2082 <sup>2</sup> | 1.2              | 26.3                        | 2.1       | 1.1       | 0.30     | 2.4              | 9.4            | 14.6                        | 118.15   |
| P- 26   | Phosphate rock                               | 2079 <sup>2</sup> | 2.1              | 26.1                        | 1.6       | 0.9       | 0.17     | 2.4              | 9.3            | 13.6                        | 120.25   |
| P- 25   | Phosphate rock                               | 2078              | 0.3              | 29.5                        | 1.1       | 0.7       | 0.08     | 3.0              | 7.1            | 10.9                        | 120.55   |
| P- 24   | Phosphate rock                               | 2077              | 1.7              | 28.6                        | 1.4       | 0.7       | 0.09     | 2.6              | 7.8            | 10.5                        | 122.25   |
| P- 23   | Phosphate rock                               | 2076              | 1.7              | 26.7                        | 1.9       | 0.8       | 0.14     | 2.7              | 9.1            | 12.3                        | 123.95   |
| P- 22   | Phosphate rock                               | 2075              | 0.8              | 21.1                        | 2.0       | 1.0       | 0.10     | 2.1              | 12.2           | 18.5                        | 124.75   |
| P- 21   | Phosphate rock, argillaceous, dolomitic      | 2074              | 0.9              | 16.4                        | 2.2       | 1.3       | 0.09     | 1.8              | 14.7           | 24.4                        | 125.65   |
|   |  |                   |                  |                             |           |           |          |                  |                |                             | 1,221.58   |

|       |  |                        |     |       |      |     |      |      |      |      |        |           |
|-------|--|------------------------|-----|-------|------|-----|------|------|------|------|--------|-----------|
| P- 20 | Phosphate rock, argillaceous,<br>dolomitic | 2073                   | 1.2 | 12.8  | 2.8  | 1.4 | 0.08 | 1.4  | 17.1 | 28.0 | 126.85 | 1, 236.94 |
| P- 19 | Phosphate rock, argillaceous,<br>dolomitic | 2072                   | 1.1 | 15.5  | 2.7  | 1.3 | 0.06 | 1.7  | 14.0 | 27.3 | 127.95 | 1, 253.99 |
| P- 18 | Dolomite, argillaceous                     | 2071                   | 0.7 | 6.9   | 2.0  | 1.2 | 0.06 | 0.82 | 26.5 | 23.8 | 128.65 | 1, 258.82 |
| P- 17 | Dolomite, phosphatic, argillaceous         | 2070                   | 0.4 | 13.3  | 1.7  | 1.1 | 0.05 | 1.6  | 19.0 | 22.7 | 129.05 | 1, 264.14 |
| P- 16 | Dolomite                                   | 2069                   | 2.3 | 5.2   | 1.2  | 0.5 | 0.05 | 0.55 | 32.6 | 16.1 | 131.35 | 1, 276.10 |
| P- 15 | Phosphate rock                             | VEM-12-47 <sup>2</sup> | 1.3 | 21.55 | 3.1  | 1.3 | 0.05 | 2.5  | 11.9 | 18.5 | 132.65 | 1, 304.11 |
| P- 14 | Dolomite                                   | VEM-11-47 <sup>2</sup> | 0.5 | 6.4   | 0.5  | 0.8 | 0.05 | 0.74 | 31.7 | 16.5 | 133.15 | 1, 307.31 |
| P- 13 | Phosphate rock, dolomitic                  | VEM-10-47 <sup>2</sup> | 0.9 | 15.69 | 1.2  | 1.2 | 0.05 | 1.6  | 20.2 | 16.2 | 134.05 | 1, 321.43 |
| P- 12 | Dolomite, phosphatic                       | VEM- 9-47 <sup>2</sup> | 0.5 | 11.5  | 0.9  | 0.9 | 0.05 | 1.3  | 27.3 | 12.2 | 134.55 | 1, 327.18 |
| P- 11 | Phosphate rock                             | VEM- 8-47 <sup>2</sup> | 0.7 | 28.9  | 1.1  | 0.7 | 0.11 | 3.4  | 9.1  | 7.9  | 135.25 | 1, 347.41 |
| P- 10 | Mudstone                                   | VEM- 7-47 <sup>2</sup> | 0.4 | 7.5   | 5.6  | 2.7 | 0.09 | 0.91 | 18.3 | 44.0 | 135.65 | 1, 350.41 |
| P- 9  | Dolomite, phosphatic, argillaceous         | 2066                   | 1.4 | 9.7   | 2.4  | 1.4 | 0.09 | 0.93 | 25.6 | 20.0 | 137.05 | 1, 363.99 |
| P- 8  | Phosphate rock, argillaceous               | 2065                   | 0.4 | 20.6  | 3.2  | 1.6 | 0.17 | 2.2  | 9.0  | 26.4 | 137.45 | 1, 372.23 |
| P- 7  | Mudstone                                   | 2064                   | 0.5 | 5.0   | 4.2  | 3.4 | 0.36 | 0.77 | 11.5 | 62.7 | 137.95 | 1, 374.73 |
| P- 6  | Mudstone, dolomitic                        | VEM- 6-47              | 2.6 | 0.26  | 7.5  | 2.5 | 0.09 | 0.12 | 14.9 | 64.7 | 140.55 | 1, 375.41 |
| P- 5  | Mudstone                                   | VEM- 5-47              | 0.5 | 0.3   | 9.7  | 3.1 | 0.04 | 0.19 | 10.7 | 73.5 | 141.05 | 1, 375.56 |
| P- 4  | Mudstone                                   | VEM- 4-47              | 0.6 | 0.44  | 9.8  | 4.6 | 0.19 | 0.29 | 12.8 | 74.7 | 141.65 | 1, 375.82 |
| P- 3  | Mudstone                                   | VEM- 3-47              | 0.5 | 0.16  | 8.8  | 3.7 | 0.11 | 0.23 | 6.6  | 81.5 | 142.15 | 1, 375.90 |
| P- 2  | Mudstone                                   | VEM- 2-47              | 1.4 | 0.67  | 10.1 | 3.1 | 0.08 | 0.25 | 6.5  | 80.3 | 143.55 | 1, 376.84 |
| P- 1  | Phosphate rock                             | VEM- 1-47              | 0.2 | 29.05 | 2.5  | 0.7 | 0.10 | 2.9  | 7.4  | 8.3  | 143.75 | 1, 382.65 |

| Wells formation |                       |    |     |    |    |    |    |    |    |    |      |    |
|-----------------|-----------------------|----|-----|----|----|----|----|----|----|----|------|----|
| Cw - 5          | Limestone, sandy      | -- | 4.3 | -- | -- | -- | -- | -- | -- | -- | 4.3  | -- |
| Cw - 4          | Limestone             | -- | 2.8 | -- | -- | -- | -- | -- | -- | -- | 7.1  | -- |
| Cw - 3          | Siltstone, calcareous | -- | 3.0 | -- | -- | -- | -- | -- | -- | -- | 10.0 | -- |
| Cw - 2          | Limestone, sandy      | -- | 3.8 | -- | -- | -- | -- | -- | -- | -- | 13.9 | -- |
| Cw - 1          | Limestone             | -- | 9.0 | -- | -- | -- | -- | -- | -- | -- | 22.9 | -- |

<sup>2</sup> See additional analyses of selected samples at end of chemical analyses tables.

Additional analyses of Coal Canyon samples

| Bed no. | Sample no. | SiO <sub>2</sub> | CaO   | MgO  | Na <sub>2</sub> O | K <sub>2</sub> O | TiO <sub>2</sub> | H <sub>2</sub> O- | CO <sub>2</sub> | S as SO <sub>3</sub> | nil |
|---------|------------|------------------|-------|------|-------------------|------------------|------------------|-------------------|-----------------|----------------------|-----|
| Rd- 1   | VEM-97-47  | 61.04            | 8.16  | 2.1  | 0.95              | 3.40             | 0.65             | 0.75              | 6.9             |                      |     |
| U- 27   | VEM-96-47  | 23.48            | 37.18 | 0.45 | 1.00              | 1.05             | 0.25             | 0.54              | 1.6             | 1.2                  |     |
| U- 26   | VEM-95-47  | 37.30            | 22.60 | 1.4  | --                | --               | --               | 0.88              | 2.3             | 0.75                 |     |
| U- 25   | VEM-94-47  | 43.60            | 19.80 | 5.4  | 0.72              | 1.22             | 0.27             | 0.30              | 13.5            | 0.43                 |     |
| U- 24   | VEM-93-47  | 74.62            | 4.70  | 0.84 | 0.97              | 1.20             | 0.34             | 0.30              | 2.9             | <0.1                 |     |
| U- 23   | VEM-92-47  | 78.46            | 3.60  | 0.51 | 0.62              | 1.50             | 0.34             | 0.30              | 0.7             | 0.22                 |     |
| U- 22   | VEM-91-47  | 65.22            | 4.00  | 0.88 | --                | --               | 0.52             | 1.23              | 0.2             | 0.32                 |     |
| U- 21   | VEM-90-47  | 59.54            | 7.32  | 1.1  | 3.10              | 0.69             | 0.49             | 1.89              | 0.5             | 0.39                 |     |
| U- 20   | VEM-89-47  | 63.04            | 5.80  | 1.2  | 0.50              | 3.50             | 0.53             | 1.31              | 0.4             | 0.26                 |     |
| U- 19   | VEM-88-47  | 65.32            | 8.36  | 2.6  | 2.20              | 0.57             | 0.35             | 0.57              | 5.9             | 0.11                 | nil |
| U- 18   | VEM-87-47  | 61.52            | 8.20  | 3.7  | 0.40              | 2.40             | 0.52             | 0.50              | 8.4             |                      |     |
| U- 17   | VEM-86-47  | 23.50            | 18.20 | 8.8  | 0.30              | 1.50             | 0.24             | 0.36              | 22.7            | <0.1                 |     |
| U- 16   | VEM-85-47  | 62.30            | 8.20  | 3.1  | 0.50              | 2.13             | 0.43             | 0.46              | 7.1             | 0.17                 |     |
| U- 15   | VEM-84-47  | 62.36            | 10.20 | 3.0  | 0.44              | 1.85             | 0.37             | 0.41              | 8.8             | 0.21                 |     |
| U- 14   | VEM-83-47  | 70.84            | 4.90  | 1.3  | 2.40              | 0.49             | 0.46             | 0.77              | 3.1             | 0.20                 |     |
| U- 13   | VEM-82-47  | 66.84            | 4.20  | 1.9  | 0.60              | 2.77             | 0.44             | 0.64              | 3.1             | 0.20                 |     |
| U- 12   | VEM-81-47  | 65.02            | 5.30  | 4.2  | 3.10              | 0.30             | 0.44             | 0.82              | 4.2             | 0.13                 |     |
| U- 11   | VEM-80-47  | 61.70            | 5.40  | 2.0  | 0.25              | 3.20             | 0.44             | 0.86              | 3.9             | 0.20                 |     |
| U- 10   | VEM-79-47  | 57.51            | 10.80 | 4.4  | 0.28              | 1.79             | 0.37             | 0.55              | 10.8            | 0.28                 |     |
| U- 9    | VEM-78-47  | 70.14            | 2.00  | 0.86 | 0.40              | 3.10             | 0.55             | 0.92              | 0.3             | 0.31                 |     |
| U- 8    | VEM-77-47  | 72.94            | 1.42  | 0.79 | 3.20              | 0.50             | 0.52             | 0.78              | 0.2             | 0.17                 |     |
| U- 7    | VEM-76-47  | 71.02            | 4.40  | 0.73 | 0.52              | 2.60             | 0.34             | 0.54              | 2.0             | 0.21                 |     |
| U- 6    | VEM-75-47  | 24.86            | 35.60 | 0.62 | 0.85              | 1.30             | 0.14             | 0.48              | 4.5             | 1.0                  |     |
| U- 5    | VEM-74-47  | 67.60            | 8.40  | 0.55 | 0.40              | 1.83             | 0.33             | 0.38              | 1.8             | 0.24                 |     |
| U- 4    | VEM-74-47  | 74.34            | 9.00  | 0.40 | 0.60              | 0.60             | 0.09             | 0.16              | 6.6             | 0.10                 |     |
| U- 3    | VEM-72-47  | 69.00            | 13.20 | 0.39 | 0.32              | 0.42             | 0.10             | 0.13              | 5.3             | 0.21                 |     |
| U- 2    | VEM-71-47  | 27.60            | 37.10 | 0.27 | 0.53              | 0.75             | 0.13             | 0.27              | 1.7             | 1.0                  |     |
| U- 1    | VEM-70-47  | 34.00            | 30.40 | 0.59 | 0.57              | 1.70             | 0.20             | 0.68              | 1.6             | 0.95                 |     |
| --      | VEM-69-47  | 61.05            | 19.00 | 1.00 | --                | --               | --               | 0.09              | 14.7            | <0.1                 |     |
| R- 7    | VEM-68-47  | 73.49            | 11.80 | 0.78 | --                | --               | --               | 0.12              | 9.6             | nil                  |     |
| R- 6    | VEM-67-47  | 72.48            | 12.00 | 0.64 | --                | --               | --               | 0.05              | 9.3             | <0.1                 |     |
| R- 5    | VEM-66-47  | 66.49            | 16.40 | 0.41 | --                | --               | --               | 0.06              | 12.7            | nil                  |     |
| R- 4    | VEM-65-47  | 73.72            | 11.50 | 0.41 | 0.89              | 2.72             | --               | 0.15              | 9.5             | <0.1                 |     |
| R- 3    | VEM-64-47  | 66.91            | 14.00 | 0.48 | --                | --               | --               | 0.08              | 11.2            | <0.1                 |     |
| R- 2    | VEM-63-47  | 87.43            | 14.00 | 0.63 | --                | --               | --               | 0.14              | 10.9            | <0.1                 |     |
| R- 1    | VEM-62-47  | 63.28            | 18.00 | 0.62 | --                | --               | --               | 0.07              | 14.1            | nil                  |     |
| P-107   | DML- 9-47  | 17.58            | 29.80 | 11.1 | 0.54              | 0.63             | 0.14             | 0.26              | 33.8            | 0.51                 |     |
| P-106   | DML- 8-47  | 17.80            | 39.40 | 0.47 | 1.50              | 1.20             | 0.20             | 0.67              | 2.6             | 2.3                  |     |

|       |                        |       |       |      |      |      |      |      |      |      |
|-------|------------------------|-------|-------|------|------|------|------|------|------|------|
| P-105 | DML- 7-47              | 61.52 | 5.60  | 0.82 | 0.35 | 3.90 | 0.01 | 0.79 | 0.9  | 0.60 |
| P-104 | DML- 6-47              | 57.58 | 9.00  | 0.67 | 0.59 | 3.30 | 0.47 | 1.02 | 0.8  | 0.91 |
| P-103 | DML- 5-47              | 61.14 | 6.60  | 0.63 | 0.40 | 3.57 | 0.45 | 1.04 | 0.6  | 0.76 |
| P-102 | DML- 4-47              | 55.26 | 9.00  | 4.2  | 0.84 | 2.53 | 0.54 | 0.43 | 10.4 | 0.31 |
| P-101 | DML- 3-47              | 57.11 | 10.40 | 0.90 | 1.02 | 1.67 | 0.43 | 0.93 | 3.2  | 0.77 |
| P-100 | DML- 2-47              | 17.70 | 40.80 | 0.39 | 1.09 | 0.80 | 0.17 | 0.62 | 3.8  | 2.0  |
| P- 99 | DML- 1-47              | 30.02 | 22.20 | 10.0 | 1.00 | 1.22 | 0.31 | 0.31 | 26.6 | 0.48 |
| P- 98 | 2063 <sub>2</sub>      | 9.91  | 46.2  | 0.24 | 0.83 | 0.60 | 0.09 | 0.50 | 4.4  | 2.3  |
| P- 97 | 2062                   | 4.73  | 49.1  | 0.20 | 1.01 | 0.39 | 0.07 | 0.46 | 2.0  | 2.9  |
| P- 96 | 2061 <sub>2</sub>      | 13.87 | 39.8  | 0.37 | 0.76 | 1.10 | 0.16 | 1.47 | 1.7  | 2.9  |
| P- 95 | 2060                   | 8.85  | 44.1  | 0.34 | 1.03 | 0.67 | 0.07 | 1.26 | 2.3  | 3.2  |
| P- 94 | 2059                   | 13.28 | 39.7  | 0.36 | 0.91 | 0.92 | 0.12 | 1.73 | 1.9  | 4.0  |
| P- 93 | 2058                   | 6.49  | 45.7  | 0.24 | 1.16 | 0.54 | 0.05 | 1.02 | 2.2  | 3.5  |
| P- 92 | VEM-61-47              | 27.10 | 32.40 | 0.39 | 1.20 | 1.80 | 0.26 | 1.12 | 1.3  | 2.8  |
| P- 91 | VEM-60-47              | 47.36 | 12.80 | 3.8  | 0.96 | 2.30 | 0.42 | 0.83 | 8.8  | 1.1  |
| P- 90 | VEM-59-47              | 32.32 | 25.60 | 4.9  | 0.90 | 1.47 | 0.01 | 0.32 | 24.8 | 0.85 |
| P- 89 | VEM-58-47              | 12.90 | 42.24 | 0.33 | 1.00 | 0.77 | 0.14 | 0.89 | 1.6  | 3.2  |
| P- 88 | VEM-57-47              | 6.70  | 48.42 | 0.41 | 1.14 | 0.45 | 0.08 | 0.56 | 11.8 | 2.3  |
| P- 87 | VEM-56-47              | 27.70 | 31.46 | 0.42 | 1.09 | 1.24 | 0.32 | 0.87 | 1.8  | 2.5  |
| P- 86 | VEM-55-47              | 15.50 | 41.60 | 0.31 | 1.25 | 0.70 | 0.16 | 0.89 | 2.1  | 2.9  |
| P- 85 | VEM-54-47              | 14.10 | 44.18 | 0.29 | 1.20 | 0.40 | 0.16 | 0.58 | 4.7  | 2.3  |
| P- 84 | VEM-53-47              | 34.24 | 25.41 | 0.43 | 1.09 | 1.60 | 0.40 | 1.08 | 2.0  | 2.4  |
| P- 83 | VEM-52-47              | 13.20 | 44.00 | 0.26 | 0.94 | 0.62 | 0.15 | 0.47 | 2.3  | 1.6  |
| P- 82 | VEM-51-47              | 35.27 | 26.80 | 2.1  | 0.74 | 1.45 | 0.19 | 0.34 | 20.8 | 0.90 |
| P- 81 | VEM-50-47              | 47.21 | 13.40 | 4.2  | 0.84 | 2.43 | 0.42 | 0.62 | 10.0 | 0.90 |
| P- 80 | VEM-49-47              | 31.21 | 26.4  | 0.90 | 0.45 | 1.89 | 0.32 | 1.35 | 9.6  | 2.1  |
| P- 79 | VEM-48-47              | 47.41 | 15.40 | 2.21 | 0.62 | 2.45 | 0.10 | 0.86 | 10.5 | 1.0  |
| P- 78 | VEM-47-47 <sub>2</sub> | 7.70  | 42.10 | 0.43 | 0.90 | 0.67 | 0.14 | 1.55 | 1.9  | 3.5  |
| P- 77 | VEM-46-47              | 21.10 | 30.80 | 1.70 | 1.00 | 1.49 | 0.26 | 1.37 | 14.0 | 2.2  |
| P- 76 | VEM-45-47              | 4.82  | 50.22 | 1.8  | 0.60 | 0.72 | 0.03 | 0.13 | 40.2 | 0.44 |
| P- 75 | VEM-44-47              | 47.18 | 8.40  | 1.9  | 1.25 | 2.12 | 0.52 | 0.51 | 5.0  | 8.6  |
| P- 74 | VEM-43-47              | 41.64 | 6.05  | 2.3  | 0.78 | 2.55 | 0.18 | 0.83 | 5.9  | 12.5 |
| P- 73 | VEM-42-47              | 45.64 | 4.20  | 2.7  | 0.99 | 2.78 | 0.23 | 0.52 | 5.1  | 10.6 |
| P- 72 | VEM-41-47              | 52.58 | 4.20  | 2.9  | 1.30 | 2.85 | 0.36 | 0.32 | 5.6  | 8.4  |
| P- 71 | VEM-40-47              | 37.36 | 15.60 | 1.4  | 1.27 | 2.11 | 0.28 | 0.37 | 6.4  | 9.4  |
| P- 70 | VEM-39-47              | 22.98 | 36.40 | 1.8  | 1.10 | 0.70 | 0.06 | 0.29 | 29.3 | 0.60 |
| P- 69 | VEM-38-47              | 48.07 | 13.20 | 0.53 | 1.30 | 2.38 | 0.48 | 1.33 | 0.52 | 1.6  |
| P- 68 | VEM-37-47              | 59.80 | 5.40  | 2.4  | 1.50 | 2.30 | 0.42 | 0.99 | 5.1  | 0.90 |
| P- 67 | VEM-36-47              | 53.23 | 9.48  | 0.48 | 1.20 | 2.62 | 0.61 | 1.41 | 0.59 | 1.6  |
| P- 66 | VEM-35-47              | 33.46 | 23.20 | 5.4  | 1.20 | 1.30 | 0.24 | 0.46 | 23.0 | 0.62 |
| P- 65 | VEM-34-47              | 35.28 | 22.2  | 1.2  | 1.20 | 2.14 | 0.38 | 1.32 | 6.1  | 2.0  |
| P- 64 | VEM-33-47              | 32.75 | 20.20 | 8.6  | 1.44 | 1.5  | 0.27 | 0.39 | 23.3 | 0.55 |
| P- 63 | VEM-32-47              | 29.90 | 24.40 | 0.80 | 1.02 | 1.95 | 0.38 | 1.62 | 5.1  | 2.2  |

<sup>2</sup> See additional analyses of selected samples at end of chemical analyses tables.

| Bed no. | Sample no.             | SiO <sub>2</sub> | CaO   | MgO  | Na <sub>2</sub> O | K <sub>2</sub> O | TiO <sub>2</sub> | H <sub>2</sub> O | CO <sub>2</sub> | S as SO <sub>3</sub> |
|---------|------------------------|------------------|-------|------|-------------------|------------------|------------------|------------------|-----------------|----------------------|
| P- 62   | VEM-31-47              | 20.82            | 28.40 | 1.0  | 0.94              | 1.35             | 0.26             | 1.85             | 7.3             | 3.0                  |
| P- 61   | VEM-30-47              | 19.60            | 32.40 | 5.3  | 0.95              | 0.95             | 0.13             | 0.45             | 30.1            | 0.56                 |
| P- 60   | VEM-29-47              | 18.63            | 25.8  | 12.3 | 1.26              | 0.97             | 0.10             | 0.54             | 30.3            | 0.80                 |
| P- 59   | VEM-28-47              | 22.60            | 26.40 | 3.4  | 0.89              | 1.70             | 0.29             | 1.76             | 7.9             | 2.5                  |
| P- 58   | VEM-27-47              | 8.27             | 29.60 | 15.1 | 0.80              | 0.50             | 0.06             | 0.77             | 36.2            | 1.0                  |
| P- 57   | VEM-26-47              | 32.60            | 20.07 | 0.63 | 0.75              | 2.60             | 0.38             | 1.86             | 0.86            | 2.5                  |
| P- 56   | VEM-25-47              | 7.82             | 29.72 | 15.0 | 0.60              | 0.71             | 0.10             | 0.43             | 36.7            | 0.60                 |
| P- 55   | VEM-24-47              | 13.10            | 32.05 | 6.1  | 0.79              | 1.22             | 0.18             | 1.23             | 14.4            | 2.5                  |
| P- 54   | VEM-23-47              | 8.69             | 31.80 | 10.9 | 0.50              | 0.66             | 0.11             | 0.58             | 32.3            | 1.1                  |
| P- 53   | VEM-22-47 <sup>3</sup> | 10.60            | 32.82 | 1.0  | 0.75              | 1.20             | 0.13             | 1.00             | 2.4             | 3.9                  |
| P- 52   | VEM-21-47              | 5.20             | 36.00 | 13.0 | 0.60              | 0.40             | 0.13             | 0.41             | 33.00           | 1.0                  |
| P- 51   | VEM-20-47              | 15.53            | 36.45 | 0.77 | 1.15              | 1.12             | 0.25             | 1.24             | 2.2             | 3.1                  |
| P- 50   | VEM-19-47              | 14.50            | 27.20 | 8.0  | 0.78              | 1.12             | 0.04             | 1.07             | 28.6            | 1.7                  |
| P- 49   | VEM-18-47              | 11.50            | 40.37 | 0.98 | 1.56              | 0.95             | 0.16             | 0.53             | 3.4             | 3.0                  |
| P- 48   | VEM-17-47              | 11.19            | 26.60 | 13.2 | 0.58              | 0.82             | 0.07             | 1.00             | 31.2            | 1.7                  |
| P- 47   | VEM-16-47              | 10.47            | 27.36 | 13.9 | 0.84              | 0.69             | 0.06             | 1.10             | 32.8            | 1.6                  |
| P- 46   | VEM-15-47              | 19.38            | 24.96 | 9.9  | 0.89              | 1.59             | 0.22             | 1.07             | 24.4            | 1.6                  |
| P- 45   | VEM-14-47              | 5.17             | 45.45 | 0.39 | 1.00              | 0.49             | 0.07             | 1.01             | 4.3             | 2.7                  |
| P- 44   | LES-10-47              | 12.80            | 38.80 | 0.58 | 1.35              | 0.79             | 0.15             | 1.46             | 2.0             | 3.8                  |
| P- 43   | LES-9-47               | 9.50             | 43.73 | 0.57 | 0.97              | 0.54             | 0.11             | 0.79             | 2.8             | 3.0                  |
| P- 42   | LES-8-47               | 14.42            | 28.40 | 12.8 | 0.70              | 0.85             | 0.11             | 0.44             | 30.6            | 0.96                 |
| P- 41   | LES-7-47               | 36.80            | 18.40 | 1.9  | 1.44              | 2.62             | 0.28             | 1.06             | 4.3             | 1.8                  |
| P- 40   | LES-6-47               | 38.32            | 16.2  | 8.4  | 1.19              | 2.17             | 0.06             | 0.59             | 19.5            | 0.63                 |
| P- 39   | LES-5-47               | 36.80            | 20.00 | 1.5  | 0.87              | 3.27             | 0.34             | 0.20             | 3.5             | 1.8                  |
| P- 38   | LES-4-47               | 25.56            | 23.2  | 12.4 | 0.45              | 0.85             | 0.06             | 0.41             | 28.6            | 0.71                 |
| P- 37   | LES-3-47               | 26.12            | 24.20 | 10.3 | 0.80              | 1.05             | 0.26             | 0.54             | 24.4            | 1.0                  |
| P- 36   | LES-2-47               | 25.76            | 24.53 | 9.1  | 1.00              | 0.97             | 0.13             | 0.60             | 22.6            | 1.2                  |
| P- 35   | LES-1-47               | 23.70            | 34.40 | 0.41 | 1.00              | 1.40             | 0.22             | 0.77             | 1.6             | 2.9                  |
| P- 34   | VEM-13-47              | 10.75            | 43.65 | 0.19 | 1.08              | 0.51             | 0.08             | 0.72             | 1.6             | 3.4                  |
| P- 33   | 2086                   | 44.45            | 12.7  | 0.64 | 0.30              | 2.73             | 0.40             | 3.88             | 1.1             | 4.5                  |
| P- 32   | 2085                   | --               | --    | 5.4  | --                | --               | --               | --               | 13.1            | 2.0                  |
| P- 31   | 2084                   | 39.01            | 27.2  | 0.39 | 0.86              | 1.81             | 0.33             | 2.10             | 1.3             | 3.7                  |
| P- 30   | 2083                   | --               | --    | 3.0  | --                | --               | --               | --               | 7.2             | 2.1                  |
| P- 29   | 2082                   | 36.23            | 21.5  | 4.8  | 1.10              | 2.03             | 0.36             | 1.19             | 11.6            | 3.1                  |
| P- 28   | 2081                   | 32.53            | 26.7  | 9.5  | 1.02              | 1.30             | 0.23             | 0.75             | 22.9            | 1.3                  |
| P- 27   | 2080 <sup>2</sup>      | 15.75            | 37.5  | 0.46 | 0.95              | 1.35             | 0.16             | 1.52             | 2.0             | 3.5                  |
| P- 26   | 2079 <sub>2</sub>      | 14.06            | 39.7  | 1.5  | 0.77              | 1.36             | 0.13             | 1.09             | 4.9             | 2.8                  |
| P- 25   | 2078                   | 12.04            | 42.9  | 0.59 | 0.72              | 0.99             | 0.10             | 0.99             | 2.5             | 2.4                  |
| P- 24   | 2077                   | 11.63            | 42.3  | 0.60 | 0.90              | 0.88             | 0.10             | 0.87             | 3.3             | 2.8                  |
| P- 23   | 2076                   | 13.36            | 41.2  | 6.80 | 0.95              | 1.07             | 0.12             | 1.22             | 3.6             | 3.1                  |
| P- 22   | 2075                   | 18.16            | 35.4  | 2.2  | 0.83              | 1.51             | 0.16             | 1.48             | 6.4             | 3.1                  |
| P- 21   | 2074                   | 22.77            | 30.4  | 3.7  | 0.70              | 1.88             | 0.21             | 1.39             | 9.8             | 2.7                  |

|       |                        |        |        |       |       |       |       |       |       |       |
|-------|------------------------|--------|--------|-------|-------|-------|-------|-------|-------|-------|
| P- 20 | 2073                   | 25. 87 | 27. 8  | 5. 0  | 0. 60 | 1. 53 | 0. 21 | 1. 30 | 12. 5 | 2. 1  |
| P- 19 | 2072                   | 25. 91 | 29. 4  | 3. 3  | 0. 63 | 2. 26 | 0. 21 | 1. 38 | 8. 6  | 2. 3  |
| P- 18 | 2071                   | 21. 20 | 26. 7  | 9. 0  | 0. 30 | 2. 29 | 0. 11 | 0. 70 | 23. 5 | 1. 1  |
| P- 17 | 2070                   | 21. 25 | 30. 9  | 5. 9  | 0. 42 | 1. 65 | 0. 31 | 0. 71 | 16. 0 | 1. 5  |
| P- 16 | 2069                   | 16. 21 | 28. 2  | 12. 2 | 0. 33 | 0. 79 | 0. 09 | 0. 59 | 33. 2 | 1. 0  |
| P- 15 | VEM-12-47 <sup>2</sup> | 16. 64 | 36. 40 | 2. 4  | 0. 83 | 1. 52 | 0. 15 | 0. 71 | 7. 1  | 2. 6  |
| P- 14 | VEM-11-47 <sup>2</sup> | 15. 20 | 30. 60 | 12. 3 | 0. 40 | 0. 78 | 0. 08 | 0. 57 | 29. 8 | 1. 1  |
| P- 13 | VEM 10-47 <sup>2</sup> | 16. 02 | 35. 00 | 6. 7  | 0. 77 | 0. 83 | 0. 17 | 0. 55 | 17. 7 | 1. 2  |
| P- 12 | VEM- 9-47 <sup>2</sup> | 13. 00 | 32. 15 | 10. 1 | 0. 62 | 0. 69 | 0. 12 | 1. 46 | 25. 3 | 2. 3  |
| P- 11 | VEM- 8-47 <sup>2</sup> | 10. 09 | 43. 82 | 0. 6  | 1. 09 | 0. 45 | 0. 16 | 0. 70 | 3. 7  | 3. 5  |
| P- 10 | VEM- 7-47 <sup>2</sup> | 39. 08 | 16. 32 | 3. 7  | 0. 45 | 2. 25 | 0. 24 | 1. 53 | 8. 0  | 2. 8  |
| P- 9  | 2066                   | 17. 98 | 26. 8  | 9. 5  | 0. 42 | 1. 31 | 0. 14 | 1. 35 | 21. 9 | 2. 1  |
| P- 8  | 2065                   | 26. 27 | 31. 1  | 0. 57 | 0. 79 | 1. 58 | 0. 19 | 1. 82 | 1. 9  | 3. 7  |
| P- 7  | 2064                   | 55. 29 | 9. 1   | 0. 80 | 0. 59 | 3. 96 | 0. 45 | 2. 36 | 0. 8  | 3. 1  |
| P- 6  | VEM- 6-47              | 53. 36 | 10. 00 | 5. 8  | 0. 40 | 4. 10 | 0. 18 | 0. 33 | 13. 3 | 0. 39 |
| P- 5  | VEM- 5-47              | 61. 56 | 4. 96  | 3. 0  | 0. 17 | 4. 63 | 0. 16 | 0. 78 | 6. 1  | 1. 5  |
| P- 4  | VEM- 4-47              | 61. 56 | 0. 64  | 0. 87 | 0. 24 | 5. 03 | 0. 11 | 1. 58 | 0. 3  | 3. 7  |
| P- 3  | VEM- 3-47              | 71. 04 | 7. 28  | 0. 72 | 0. 30 | 5. 07 | 0. 10 | 0. 95 | 0. 3  | 1. 6  |
| P- 2  | VEM- 2-47              | 69. 28 | 2. 60  | 1. 4  | 0. 35 | 4. 50 | 0. 18 | 0. 75 | 2. 3  | 1. 1  |
| P- 1  | VEM- 1-47              | 10. 20 | 42. 24 | 1. 9  | 0. 95 | 0. 40 | 0. 07 | 0. 42 | 5. 1  | 2. 2  |

<sup>2</sup> See additional analyses of selected samples on next page.

<sup>3</sup> The SiO<sub>2</sub> analysis for this sample is probably in error.

Additional analyses of selected samples<sup>4</sup>

| Bed no. | Sample no. | P <sub>2</sub> O <sub>5</sub>  | V <sub>2</sub> O <sub>5</sub> | F     | SiO <sub>2</sub>                                     | TiO <sub>2</sub>                            | CaO                                  | MgO                        | Na <sub>2</sub> O          | K <sub>2</sub> O              | MnO                                 | Ni             |
|---------|------------|--------------------------------|-------------------------------|-------|--|---|--------------------------------------|----------------------------|----------------------------|-------------------------------|-------------------------------------|----------------|
|         |            | --                             | --                            | --    | 10.06<br>3.03<br>3.13<br>2.43<br>2.61<br>12.63<br>-- | 0.06<br>0.04<br>0.08<br>0.22<br>38.96<br>-- | 41.73<br>42.10<br>2.36<br>0.91<br>-- | 0.73<br>0.80<br>0.91<br>-- | 0.96<br>0.55<br>1.16<br>-- | 0.003<br>0.009<br>0.005<br>-- | --<br>0.002<br>0.003<br>0.002<br>-- |                |
| P-98    | 2063       | 28.77                          | 0.31                          | 3.03  | 10.06<br>3.03<br>3.13<br>2.43<br>2.61<br>12.63<br>-- | 0.06<br>0.04<br>0.08<br>0.22<br>38.96<br>-- | 41.73<br>42.10<br>2.36<br>0.91<br>-- | 0.73<br>0.80<br>0.91<br>-- | 0.96<br>0.55<br>1.16<br>-- | 0.003<br>0.009<br>0.005<br>-- | --<br>0.002<br>0.003<br>0.002<br>-- |                |
| P-96    | 2061       | 29.89                          | 0.05                          | 0.05  | 10.06<br>3.03<br>3.13<br>2.43<br>2.61<br>12.63<br>-- | 0.06<br>0.04<br>0.08<br>0.22<br>38.96<br>-- | 41.73<br>42.10<br>2.36<br>0.91<br>-- | 0.73<br>0.80<br>0.91<br>-- | 0.96<br>0.55<br>1.16<br>-- | 0.003<br>0.009<br>0.005<br>-- | --<br>0.002<br>0.003<br>0.002<br>-- |                |
| P-78    | VEM-47-47  | 26.33                          | 0.28                          | 0.28  | 10.06<br>3.03<br>3.13<br>2.43<br>2.61<br>12.63<br>-- | 0.06<br>0.04<br>0.08<br>0.22<br>38.96<br>-- | 41.73<br>42.10<br>2.36<br>0.91<br>-- | 0.73<br>0.80<br>0.91<br>-- | 0.96<br>0.55<br>1.16<br>-- | 0.003<br>0.009<br>0.005<br>-- | --<br>0.002<br>0.003<br>0.002<br>-- |                |
| P-27    | 2080       | --                             | --                            | --    | --   | --  | --                                   | --                         | --                         | --                            | --                                  | --             |
| P-26    | 2079       | --                             | --                            | --    | --   | --  | --                                   | --                         | --                         | --                            | --                                  | --             |
| P-12    | 2068       | --                             | --                            | --    | --   | --  | --                                   | --                         | --                         | --                            | --                                  | --             |
| to 15   | 2065       | 18.48                          | 0.10                          | 2.01  | 16.13  | 0.08  | 31.48                                | 4.21                       | 0.65                       | 1.16                          | 0.035                               | 0.039          |
| P-10    | 2066       | --                             | --                            | --    | --   | --  | --                                   | --                         | --                         | --                            | --                                  | --             |
| to 11   | 2067       | --                             | --                            | --    | --   | --  | --                                   | --                         | --                         | --                            | --                                  | --             |
|         |            | Cr <sub>2</sub> O <sub>3</sub> | Co                            | Zn    | Cu   | Pb  | Ag                                   | MoO <sub>3</sub>           | W                          | C1                            |                                     | Organic matter |
|         |            | --                             | --                            | --    | --   | --  | --                                   | 0.0001                     | --                         | --                            | --                                  | --             |
|         |            | 0.14                           | 0.004                         | 0.008 | 0.003  | 0.001                                       | 0.0001                               | 0.002                      | --                         | 0.004                         | 5.28 <sup>7</sup>                   |                |
|         |            | 0.28                           | 0.006                         | 0.001 | 0.013  | 0.005                                       | 0.0002                               | 0.002                      | --                         | --                            | 7.18 <sup>7</sup>                   |                |
|         |            | 0.08                           | 0.004                         | 0.010 | 0.006  | 0.001                                       | 0.0002                               | 0.012                      | --                         | 0.004                         | 5.82 <sup>7</sup>                   |                |
|         |            | --                             | --                            | --    | --   | --  | 0.0003                               | --                         | --                         | --                            | --                                  | --             |
|         |            | --                             | --                            | --    | --   | --  | 0.0003                               | 0.002                      | <0.005                     | 0.005                         | 4.64 <sup>8</sup>                   |                |
|         |            | 0.12                           | 0.004                         | 0.002 | 0.020  | 0.005                                       | 0.0004                               | 0.004                      | <0.002                     | <0.005                        | --                                  | --             |

<sup>4</sup> Analyses made by U. S. Geological Survey, Geochemistry and Petrology Branch.

<sup>5</sup> Sample no. 2068 is a composite of samples VEM-9-47 through VEM-12-47.

<sup>6</sup> Sample no. 2067 is a composite of samples VEM-7-47 and VEM-8-47.

<sup>7</sup> CO<sub>2</sub> and S reported present.

<sup>8</sup> CO<sub>2</sub> reported present, strong, and S reported present.

SPECTROGRAPHIC ANALYSES—COAL CANYON, WYOMING. LOT NO. 1201.

Semi-quantitative analyses of samples of the phosphatic shale member of Phosphoria formation, Coal Canyon, Wyoming (see immediately preceding pages for location of section, thickness and description of strata, and chemical analyses of samples), made by U. S. Bureau of Mines Laboratory, Albany, Oregon. In addition to the elements listed in the table below, Sb, As, Bi, Cd, Co, Ga, Au, Li, Hg, Pt, Ta, Sn, and W were looked for in all samples but were not detected.

Explanation of symbols

A = more than 10 percent  
 B = 5-10 percent  
 C = 1-5 percent  
 D = 0.1-1 percent  
 E = 0.01-0.1 percent  
 F = 0.001-0.01 percent  
 G = less than 0.001 percent  
 ND = not detected

| Bed no. | Sample no. | A1 | Ba | Be | B | Ca | Cr | Cb | Cu | Fe | Pb | Mg | Mn | Mo | Ni | Si | Ag | Na | Sr | Ti | V  | Zn | Zr |
|---------|------------|----|----|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| P-107   | DML-9-47   | C  | ND | F  | A | F  | ND | G  | D  | E  | F  | F  | F  | F  | B  | ND | E  | ND | F  | F  | ND | F  | F  |
| P-106   | DML-8-47   | C  | ND | F  | A | C  | ND | G  | D  | ND | D  | D  | F  | F  | E  | B  | ND | E  | E  | E  | ND | E  | E  |
| P-105   | DML-7-47   | C  | ND | F  | C | C  | ND | G  | D  | ND | D  | D  | F  | F  | E  | A  | ND | D  | D  | E  | ND | E  | E  |
| P-104   | DML-6-47   | C  | ND | F  | C | C  | ND | G  | D  | ND | D  | D  | F  | F  | E  | A  | ND | D  | D  | E  | ND | E  | E  |
| P-103   | DML-5-47   | C  | ND | F  | C | C  | ND | G  | D  | ND | D  | D  | F  | F  | E  | A  | ND | D  | D  | E  | ND | E  | E  |
| P-102   | DML-4-47   | C  | ND | F  | C | C  | ND | G  | D  | ND | D  | D  | F  | F  | E  | E  | A  | ND | D  | D  | E  | ND | E  |
| P-101   | DML-3-47   | C  | ND | F  | A | E  | ND | G  | D  | ND | D  | D  | F  | F  | F  | B  | ND | D  | D  | E  | ND | E  | E  |
| P-100   | DML-2-47   | C  | ND | F  | B | F  | ND | G  | D  | ND | D  | D  | F  | F  | F  | A  | ND | D  | D  | E  | ND | E  | E  |
| P- 99   | DML-1-47   | C  | ND | F  | A | E  | ND | G  | D  | ND | D  | D  | F  | F  | F  | C  | E  | ND | D  | E  | ND | E  | E  |
| P- 98   | 2063       | C  | ND | F  | G | E  | ND | F  | D  | E  | D  | E  | F  | F  | E  | B  | G  | D  | E  | E  | E  | ND | E  |
| P- 97   | 2062       | D  | E  | G  | E | E  | ND | F  | C  | E  | D  | E  | D  | E  | E  | A  | G  | D  | E  | E  | E  | ND | E  |
| P- 96   | 2061       | D  | E  | G  | E | E  | ND | F  | A  | E  | D  | E  | D  | F  | E  | E  | C  | D  | D  | E  | E  | ND | E  |
| P- 95   | 2060       | C  | ND | F  | A | A  | ND | G  | D  | D  | ND | D  | D  | F  | F  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 94   | 2059       | C  | ND | F  | A | E  | ND | G  | E  | E  | ND | D  | D  | F  | F  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 93   | 2058       | C  | ND | F  | E | C  | ND | G  | D  | E  | ND | D  | D  | F  | F  | E  | E  | ND | D  | E  | E  | ND | F  |
| P- 92   | VEM-61-47  | C  | E  | G  | E | C  | ND | F  | A  | D  | ND | E  | D  | E  | E  | F  | ND | D  | D  | E  | E  | ND | F  |
| P- 91   | VEM-60-47  | C  | E  | G  | E | C  | ND | F  | B  | E  | ND | G  | D  | D  | D  | C  | G  | ND | D  | D  | E  | ND | F  |
| P- 90   | VEM-59-47  | D  | ND | F  | D | ND | ND | F  | C  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 89   | VEM-58-47  | D  | ND | F  | D | ND | ND | F  | D  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 88   | VEM-57-47  | D  | ND | F  | D | ND | ND | F  | D  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 87   | VEM-56-47  | C  | E  | ND | F | A  | ND | F  | A  | E  | ND | G  | D  | D  | D  | F  | ND | D  | D  | E  | E  | ND | F  |
| P- 86   | VEM-55-47  | D  | ND | F  | D | E  | ND | F  | B  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 85   | VEM-54-47  | D  | ND | F  | C | E  | ND | F  | A  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 84   | VEM-53-47  | C  | E  | ND | F | D  | ND | F  | B  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 83   | VEM-52-47  | D  | ND | F  | D | ND | ND | F  | A  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 82   | VEM-51-47  | C  | E  | ND | F | A  | ND | F  | E  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 81   | VEM-50-47  | C  | E  | ND | F | A  | ND | F  | B  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 80   | VEM-49-47  | C  | E  | ND | F | A  | ND | F  | A  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 79   | VEM-48-47  | C  | E  | ND | F | B  | ND | F  | B  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |
| P- 78   | VEM-47-47  | D  | E  | ND | F | A  | ND | F  | E  | E  | ND | G  | D  | D  | D  | F  | F  | ND | D  | E  | E  | ND | F  |

| Bed no. | Sample no. | Al | Ba | Be | B | Ca | Cr | Cb | Cu | Fe | Pb | Mg | Mn | Mo | Ni | Si | Ag | Na | Sr | Ti | V | Zn | Zr |
|---------|------------|----|----|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|----|----|
| P- 77   | VEM-46-47  | C  | D  | ND | G | E  | E  | ND | G  | D  | ND | D  | D  | E  | E  | C  | E  | ND | F  | F  | F | F  | F  |
| P- 76   | VEM-45-47  | D  | C  | ND | E | A  | A  | ND | F  | E  | ND | D  | D  | D  | E  | D  | D  | D  | E  | E  | E | E  | E  |
| P- 75   | VEM-44-47  | C  | C  | ND | G | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 74   | VEM-43-47  | C  | C  | ND | G | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 73   | VEM-42-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 72   | VEM-41-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 71   | VEM-40-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 70   | VEM-39-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 69   | VEM-38-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 68   | VEM-37-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 67   | VEM-36-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 66   | VEM-35-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 65   | VEM-34-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 64   | VEM-33-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 63   | VEM-32-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 62   | VEM-31-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 61   | VEM-30-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 60   | VEM-29-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 59   | VEM-28-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 58   | VEM-27-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 57   | VEM-26-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 56   | VEM-25-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 55   | VEM-24-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 54   | VEM-23-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 53   | VEM-22-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 52   | VEM-21-47  | D  | D  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 51   | VEM-20-47  | D  | D  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 50   | VEM-19-47  | D  | D  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 49   | VEM-18-47  | D  | D  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 48   | VEM-17-47  | D  | D  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 47   | VEM-16-47  | D  | D  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 46   | VEM-15-47  | D  | D  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 45   | VEM-14-47  | D  | D  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 44   | LES- 10-47 | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 43   | LES- 9-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 42   | LES- 8-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 41   | LES- 7-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 40   | LES- 6-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 39   | LES- 5-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 38   | LES- 4-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 37   | LES- 3-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |
| P- 36   | LES- 2-47  | C  | C  | ND | F | E  | E  | ND | F  | E  | ND | D  | D  | D  | D  | D  | D  | D  | D  | D  | D | D  | D  |



## NORTH FORK OF PINE CREEK, WYOMING. LOT NO. 1204.

Phosphatic shale member of Phosphoria formation sampled in bulldozer trench on North Fork of Pine Creek, sec. 13, T. 25 N., R. 118 W., Lincoln County, Wyoming, 10 miles northeast of Cokeville on east limb of syncline. Beds strike N. 10°-25° E. and dip 37°-45° W. Section measured by R. A. Hoppin, V. E. McKelvey, and L. E. Smith and sampled by R. P. Sheldon, O. A. Payne, and R. S. Sears in June and July 1947. Samples analyzed for  $P_2O_5$  and acid insoluble by U. S. Bureau of Mines Laboratory, Albany, Oregon, and for other constituents by Trace Elements Section Laboratory, U. S. Geological Survey, Washington, D. C.

| Bed no.   | Rock description                                | Sample no. | Thickness (feet) | Chemical analyses (percent) |           |           | Cumulative thickness (feet) | Thickness x percent $P_2O_5$ (cumulative) |
|---|---|------------|------------------|-----------------------------|-----------|-----------|-----------------------------|---|
|   |   |            |                  | $P_2O_5$                    | $Al_2O_3$ | $Fe_2O_3$ |                             |   |
| Phosphatic shale member of Phosphoria formation |   |            |                  |                             |           |           |                             |   |
| P-83  | Mudstone, calcareous                            | RAH-63-47  | 2.2              | 0.3                         | --        | --        | 67.8                        | 0.66                                      |
| P-82  | Mudstone, calcareous                            | RAH-62-47  | 2.4              | 0.3                         | --        | --        | 50.7                        | 18.42                                     |
| P-81  | Limestone, argillaceous; fos. col. no. 47-HW-54 | RAH-61-47  | 2.5              | 6.3                         | --        | --        | 27.3                        | 34.17                                     |
| P-80  | Limestone, argillaceous; fos. col. no. 47-HW-53 | RAH-60-47  | 1.5              | 0.6                         | --        | --        | 44.0                        | 35.07                                     |
| P-79  | Limestone, argillaceous; fos. col. no. 47-HW-52 | RAH-59-47  | 1.9              | 0.7                         | --        | --        | 41.9                        | 36.40                                     |
| P-78  | Mudstone, calcareous; fos. col. no. 47-HW-51    | RAH-58-47  | 2.7              | 1.2                         | --        | --        | 60.9                        | 39.64                                     |
| P-77  | Mudstone, calcareous; fos. col. no. 47-HW-50    | RAH-57-47  | 1.6              | 0.7                         | --        | --        | 59.0                        | 40.76                                     |
| P-76  | Mudstone, calcareous                            | RAH-56-47  | 1.0              | 0.7                         | --        | --        | 60.0                        | 41.46                                     |
| P-75  | Limestone, argillaceous                         | RAH-55-47  | 3.2              | 0.6                         | --        | --        | 49.7                        | 43.38                                     |
| P-74  | Mudstone  | RAH-54-47  | 3.8              | 1.0                         | --        | --        | 82.7                        | 47.18                                     |
| P-73  | Mudstone, phosphatic; fos. col. no. 47-HW-21    | RAH-53-47  | 0.9              | 13.3                        | --        | --        | 61.1                        | 23.7                                      |
| P-72  | Mudstone; fos. col. no. 47-HW-20                | RAH-52-47  | 4.4              | 4.7                         | --        | --        | 83.6                        | 79.83                                     |
| P-71  | Mudstone  | RAH-51-47  | 2.6              | 4.3                         | --        | --        | 74.6                        | 91.01                                     |
| P-70  | Mudstone, calcareous                            | RAH-50-47  | 1.4              | 2.3                         | --        | --        | 65.7                        | 94.23                                     |
| P-69  | Mudstone  | RAH-49-47  | 1.3              | 3.3                         | --        | --        | 79.6                        | 98.52                                     |
| P-68  | Phosphate rock                                  | RAH-48-47  | 3.5              | 34.7                        | 1.2       | 0.45      | 3.40                        | 5.3                                       |
| P-67  | Mudstone, calcareous                            | RAH-47-47  | 1.4              | 2.8                         | 9.72      | 1.7       | 6.44                        | 72.2                                      |
| P-66  | Phosphate rock, argillaceous                    | RAH-46-47  | 4.4              | 25.9                        | 3.5       | 0.89      | 3.92                        | 23.4                                      |
| P-65  | Phosphate rock, argillaceous, loc. 47-HW-10     | RAH-45-47  | 1.0              | 30.1                        | 2.9       | 1.3       | 2.78                        | 33.7                                      |
| P-64  | Muds ore  | RAH-44-47  | 1.3              | 1.4                         | --        | --        | 84.8                        | 43.7                                      |
| P-63  | Mudstone  | LES-116-47 | 1.4              | 3.3                         | --        | --        | 77.0                        | 46.8                                      |
| P-62  | Mudstone  | LES-115-47 | 0.9              | 1.0                         | --        | --        | 84.3                        | 47.7                                      |
| P-61  | Phosphate rock, argillaceous                    | LES-114-47 | 0.4              | 24.1                        | --        | --        | 24.9                        | 48.1                                      |
| P-60  | Mudstone, phosphatic                            | LES-113-47 | 0.6              | 13.6                        | --        | --        | 47.2                        | 48.7                                      |
| P-59  | Mudstone  | LES-112-47 | 1.0              | 1.1                         | --        | --        | 78.6                        | 49.7                                      |
| P-58  | Phosphate rock, calcareous, argillaceous        | LES-111-47 | 0.4              | 20.8                        | --        | --        | 22.7                        | 50.1                                      |
| P-57  | Mudstone, phosphatic                            | LES-110-47 | 0.55             | 14.4                        | --        | --        | 39.4                        | 50.65                                     |
| P-56  | Limestone, argillaceous, phosphatic             | LES-109-47 | 0.5              | 9.2                         | --        | --        | 35.0                        | 51.15                                     |

|  |   |  |                                     |                                 |                            |                            |                                      |  |
|--|---|--|-------------------------------------|---------------------------------|----------------------------|----------------------------|--------------------------------------|--|
| P-55   | Limestone, argillaceous; fos. col.<br>no. 47-HW-18  | LES-108-47<br>LES-107-47<br>LES-106-47<br>LES-105-47<br>LES-354-47 | 1.4<br>0.5<br>0.45<br>0.95<br>(0.5) | 3.8<br>0.5<br>0.2<br>0.2<br>0.3 | --<br>--<br>--<br>--<br>-- | --<br>--<br>--<br>--<br>-- | 22.6<br>67.3<br>71.6<br>80.1<br>78.0 | 52.55<br>53.05<br>53.50<br>54.45<br>-- |
| LES-354-47 represents the upper half of LES-105, bed P-52. |   |  |                                     |                                 |                            |                            |                                      |  |
| P-51   | Mudstone  | LES-104-47   | 1.0                                 | 6.3                             | --                         | --                         | 55.9                                 | 55.45                                  |
| P-50   | Mudstone, calcareous; fos. col. no.<br>47-HW-17   | LES-103-47<br>LES-102-47<br>LES-101-47<br>LES-100-47               | 0.7<br>0.7<br>0.7<br>3.0            | 2.1<br>1.3<br>12.5<br>0.4       | --<br>--<br>--<br>--       | --<br>--<br>--<br>--       | 51.7<br>84.6<br>51.1<br>46.7         | 428.49<br>429.96<br>430.87<br>439.62   |
| P-49   | Mudstone  | LES-98-47<br>LES-97-47   | 2.0<br>3.6                          | 0.9<br>10.0<br>6.7              | --<br>--<br>--             | --<br>--<br>--             | 63.0<br>49.8<br>56.0                 | 442.62<br>462.62<br>486.74             |
| P-48   | Mudstone, phosphatic  | LES-96-47  | 3.9                                 | 15.2                            | --                         | --                         | 30.1                                 | 72.05                                  |
| P-47   | Mudstone, calcareous  | LES-95-47  | 2.8                                 | 1.0                             | --                         | --                         | 28.3                                 | 74.85                                  |
| P-46   | Mudstone, calcareous  | LES-94-47  | 1.9                                 | 16.4                            | --                         | --                         | 35.9                                 | 579.98                                 |
| P-45   | Mudstone, phosphatic  | LES-93-47  | 1.0                                 | 8.4                             | --                         | --                         | 34.7                                 | 588.38                                 |
| P-44   | Mudstone, calcareous  | LES-92-47  | 2.1                                 | 17.6                            | --                         | --                         | 33.8                                 | 625.34                                 |
| P-43   | Phosphate rock, argillaceous, contains<br>calcareous concretions; fos. col.<br>no. 47-HW-41 | LES-91-47  | 0.5                                 | 16.3                            | --                         | --                         | 35.7                                 | 633.49                                 |
| P-42   | Limestone, argillaceous; fos. col. no.<br>47-HW-16  | LES-90-47  | 0.75                                | 19.0                            | --                         | --                         | 26.7                                 | 647.74                                 |
| P-41   | Phosphate rock, argillaceous, calcareous  | LES-89-47  | 3.0                                 | 4.7                             | --                         | --                         | 22.2                                 | 661.84                                 |
| P-40   | Limestone, argillaceous, phosphatic   | LES-88-47  | 0.7                                 | 5.5                             | --                         | --                         | 77.8                                 | 665.69                                 |
| P-39   | Phosphate rock, argillaceous, calcareous  | LES-87-47  | 0.8                                 | 13.7                            | --                         | --                         | 51.4                                 | 676.65                                 |
| P-38   | Phosphate rock, argillaceous, calcareous  | LES-86-47  | 0.5                                 | 26.1                            | --                         | --                         | 20.4                                 | 689.70                                 |
| P-37   | Phosphate rock, argillaceous, calcareous,<br>contains chert lenses                          | LES-85-47  | 2.15                                | 33.0                            | --                         | --                         | 8.6                                  | 760.65                                 |
| P-36   | Limestone, argillaceous   | LES-84-47  | 0.5                                 | 18.0                            | --                         | --                         | 39.1                                 | 769.65                                 |
| P-35   | Chert, contains quartz vugs; fos. col.<br>no. 47-HW-15                                      | LES-83-47  | 2.3                                 | 13.1                            | --                         | --                         | 41.8                                 | 799.78                                 |
| P-34   | Mudstone, phosphatic  | LES-82-47  | 2.2                                 | 0.6                             | --                         | --                         | 35.1                                 | 801.10                                 |
| P-33   | Phosphate rock, silty and mudstone  | LES-81-47  | 0.8                                 | 7.8                             | --                         | --                         | 51.0                                 | 807.35                                 |
| P-32   | Phosphate rock  | LES-80-47  | 0.8                                 | 5.7                             | --                         | --                         | 30.0                                 | 94.85                                  |
| P-31   | Phosphate rock, argillaceous  | LES-79-47  | 0.85                                | 30.2                            | --                         | --                         | 12.9                                 | 837.57                                 |
| P-30   | Mudstone, phosphatic, calcareous  | LES-78-47  | 0.3                                 | 4.8                             | --                         | --                         | 62.1                                 | 839.01                                 |
| P-29   | Limestone, argillaceous   | LES-77-47  | 1.2                                 | 0.4                             | --                         | --                         | 70.5                                 | 839.49                                 |
| P-28   | Mudstone, calcareous, phosphatic  | LES-76-47  | 0.35                                | 3.8                             | --                         | --                         | 71.2                                 | 840.82                                 |
| P-27   | Limestone, argillaceous, contains chert<br>lenses   | LES-75-47  | 1.6                                 | 5.4                             | --                         | --                         | 73.7                                 | 849.46                                 |

| Bed no.         | Rock description                           | Sample no. | Thickness (feet) | Chemical analyses (percent)   |                                |                                |                  | Cumulative thickness (feet) | Thickness x percent P <sub>2</sub> O <sub>5</sub> (cumulative,) |
|-----------------|--|------------|------------------|-------------------------------|--------------------------------|--------------------------------|------------------|-----------------------------|---|
|                 |  |            |                  | P <sub>2</sub> O <sub>5</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | Loss on ignition |                             |   |
| P-21            | Mudstone                                   | LES- 74-47 | 0.75             | 1.7                           | --                             | --                             | --               | 83.9                        | 99.90   |
| P-20            | Phosphate rock                             | LES- 73-47 | 0.9              | 31.7                          | --                             | --                             | --               | 15.6                        | 100.80  |
| P-19            | Mudstone, contains chert lenses            | LES- 72-47 | 4.0              | 1.0                           | --                             | --                             | --               | 92.7                        | 104.80  |
| P-18            | Mudstone and chert                         | LES- 71-47 | 1.8              | 1.0                           | --                             | --                             | --               | 85.8                        | 106.60  |
| P-17            | Mudstone, calcareous and chert             | LES- 58-47 | 2.0              | 0.6                           | --                             | --                             | --               | 43.9                        | 108.60  |
| P-16            | Mudstone, calcareous and chert             | LES- 57-47 | 1.9              | 1.1                           | --                             | --                             | --               | 60.6                        | 110.50  |
| P-15            | Mudstone, calcareous and chert             | LES- 56-47 | 1.5              | 1.1                           | --                             | --                             | --               | 66.6                        | 112.00  |
| P-14            | Mudstone, calcareous and chert             | LES- 55-47 | 1.2              | 1.2                           | --                             | --                             | --               | 48.7                        | 113.20  |
| P-13            | Limestone, argillaceous and phosphate rock | LES- 54-47 | 0.7              | 6.3                           | --                             | --                             | --               | 26.0                        | 113.90  |
| P-12            | Limestone, argillaceous                    | LES- 53-47 | 0.85             | 1.9                           | --                             | --                             | --               | 25.4                        | 114.75  |
| P-11            | Mudstone, calcareous                       | LES- 52-47 | 1.8              | 6.8                           | --                             | --                             | --               | 52.7                        | 116.55  |
| P-10            | Limestone, argillaceous                    | LES- 51-47 | 0.65             | 2.2                           | --                             | --                             | --               | 19.0                        | 117.20  |
| P- 9            | Mudstone, phosphatic                       | LES- 50-47 | 0.85             | 13.2                          | --                             | --                             | --               | 46.3                        | 118.05  |
| P- 8            | Mudstone, calcareous                       | LES- 49-47 | 0.45             | 3.9                           | --                             | --                             | --               | 57.4                        | 118.50  |
| P- 7            | Limestone, argillaceous                    | LES- 48-47 | 1.9              | 0.6                           | --                             | --                             | --               | 34.9                        | 120.40  |
| P- 6            | Mudstone, calcareous                       | LES- 47-47 | 0.5              | 1.3                           | --                             | --                             | --               | 74.0                        | 120.90  |
| P- 5            | Limestone, argillaceous                    | VEM-104-47 | 1.9              | 0.4                           | --                             | --                             | --               | 33.0                        | 122.80  |
| P- 4            | Mudstone                                   | VEM-103-47 | 0.5              | 1.1                           | --                             | --                             | --               | 75.6                        | 123.30  |
| P- 3            | Mudstone, calcareous                       | VEM-102-47 | 1.9              | 0.4                           | --                             | --                             | --               | 57.9                        | 125.20  |
| P- 2            | Limestone, argillaceous                    | VEM-101-47 | 1.1              | 0.4                           | --                             | --                             | --               | 45.4                        | 126.30  |
| P- 1            | Phosphate rock, mudstone, and chert        | VEM-100-47 | 0.4              | 26.4                          | --                             | --                             | --               | 17.4                        | 126.70  |
| Wells formation |  |            |                  |                               |                                |                                |                  |                             |   |
| Cw-2            | Sandstone, phosphatic                      | VEM- 99-47 | 1.4              | 12.0                          | --                             | --                             | --               | 56.1                        | 1.4   |
| Cw-1            | Mudstone, calcareous                       | VEM- 98-47 | 1.9              | 1.0                           | --                             | --                             | --               | 53.6                        | 3.3   |

SPECTROGRAPHIC ANALYSES—NORTH FORK OF PINE CREEK, WYOMING. LOT NO. 1204.

Semi-quantitative analyses of a few samples of the Phosphoria formation, North Fork of Pine Creek, Wyoming (see immediately preceding pages for location of section, thickness and description of strata, and chemical analyses of samples), made by the U. S. Geological Survey Laboratory, Geochemistry and Petrology Branch. In addition to the elements listed in the table below, Sb, As, Be, Bi, Cd, Ce, Cs, Co, Cb, Ge, In, Hg, Mo, Nd, Pt, Re, Rb, Sc, Ta, Tl, Th, and W were looked for in all samples but were not detected.

Explanation of symbols

|    |                        |                             |
|----|------------------------|-----------------------------|
| A  | * more than 10 percent | F = 0.001-0.01 percent      |
| B' | = 1-10 percent         | G = less than 0.001 percent |
| D  | = 0.01-0.1 percent     |                             |
| E  | * 0.01-0.1 percent     | ND = not detected           |

| Bed no. | Sample no. | Al | Ba | B | Ca | Cr | Cu | Fe | La | Pb | Mg | Mn | Ni | r  | Si | Ag | Na | Sr | Sn | Ti | V  | Y | Zn | Zr |
|---------|------------|----|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|----|----|
| P-68    | RAH-48-47  | D  | F  | F | A  | D  | F  | D  | E  | D  | F  | F  | F  | -- | B' | G  | D  | D  | F  | E  | E  | F | E  |    |
| P-67    | RAH-47-47  | -- | F  | F | B  | E  | F  | D  | ND | E  | D  | E  | F  | B' | A  | G  | D  | D  | F  | E  | ND | F | E  |    |
| P-66    | RAH-46-47  | D  | F  | F | A  | D  | F  | D  | E  | F  | D  | E  | F  | F  | A  | B' | G  | D  | D  | F  | E  | E | F  |    |
| P-65    | RAH-45-47  | D  | F  | F | A  | E  | F  | D  | E  | F  | D  | E  | F  | F  | A  | B' | G  | D  | D  | F  | E  | E | F  |    |

1

B' is equivalent to B and C of Bureau of Mines analyses.

## MIDDLE FORK OF PINE CREEK, WYOMING. LOT NO. 1205.

Phosphoria formation sampled on north wall of Middle Fork of Pine Creek, sec. 35, T. 25 N., R. 118 W., Lincoln County, Wyoming, on west-dipping Tump Range monocline. Beds R-26 to U-30 sampled in trench 150 feet above creek, all other beds in trench 50-200 feet above creek. Beds R-1 to R-25 measured in natural exposures 150-400 feet above creek. Beds strike N. 10° E. and dip 26° W. Section measured by R. A. Hoppin, F. C. Armstrong, and L. E. Smith and sampled by R. S. Sears and O. A. Payne in June, July, and August 1947. Samples analyzed for  $P_2O_5$  and acid insoluble by U. S. Bureau of Mines Laboratory, Albany, Oregon, and for other constituents by Trace Elements Section Laboratory, U. S. Geological Survey, Washington, D. C.

| Bed no.                                    | Rock description  | Sample no.  | Thickness (feet) | Chemical analyses (percent) |           |           |                  | Cumulative thickness (feet) | Thickness x percent $P_2O_5$ (cumulative) |
|--|---|---|------------------|-----------------------------|-----------|-----------|------------------|-----------------------------|---|
|  |   |   |                  | $P_2O_5$                    | $Al_2O_3$ | $Fe_2O_3$ | Loss on ignition |                             |   |
| Dinwoody formation                         |   |   |                  |                             |           |           |                  |                             |   |
| T-d-1                                      | Mudstone, calcareous, fos. col. nos. 47-HW-31 and 47-HW-31A <sup>1</sup>        | --  | 1.1              | --                          | --        | --        | --               | --                          | 1.1                                       |
| Upper shale member of Phosphoria formation |   |   |                  |                             |           |           |                  |                             |   |
| U-30                                       | Phosphate rock, argillaceous, calcareous; fos. col. nos. 47-HW-30 and 47-HW-30A | RAH-43-47   | 2.2              | 18.0                        | --        | --        | --               | 29.1                        | 2.2                                       |
| U-29                                       | Chert, calcareous, phosphatic   | RAH-42-47   | 1.9              | 8.2                         | --        | --        | --               | 47.0                        | 4.1                                       |
| U-28                                       | Chert, calcareous   | RAH-41-47   | 1.1              | 1.6                         | --        | --        | --               | 51.3                        | 5.2                                       |
| U-27                                       | Chert, calcareous   | RAH-40-47   | 2.8              | 0.9                         | --        | --        | --               | 64.6                        | 8.0                                       |
| U-26                                       | Chert, calcareous   | RAH-39-47   | 1.0              | 1.1                         | --        | --        | --               | 62.4                        | 9.0                                       |
| U-25                                       | Mudstone, calcareous  | RAH-38-47   | 1.1              | 1.7                         | --        | --        | --               | 60.7                        | 10.1                                      |
| U-24                                       | Mudstone, calcareous  | RAH-37-47   | 1.4              | 4.4                         | --        | --        | --               | 56.1                        | 11.5                                      |
| 28   | Mudstone, calcareous, phosphatic, calcareous                                    | RAH-36-47   | 0.6              | 13.1                        | --        | --        | --               | 41.0                        | 12.1                                      |
| U-23                                       | Chert, calcareous   | RAH-35-47   | 1.6              | 1.7                         | --        | --        | --               | 60.6                        | 13.7                                      |
| U-22                                       | Chert, calcareous   | RAH-34-47   | 0.7              | 2.3                         | --        | --        | --               | 62.3                        | 14.4                                      |
| U-21                                       | Chert, calcareous   | RAH-33-47   | 0.7              | 2.0                         | --        | --        | --               | 65.2                        | 8.2                                       |
| U-20                                       | Chert, calcareous   | RAH-32-47   | 1.0              | 1.6                         | --        | --        | --               | 65.2                        | 15.1                                      |
| U-19                                       | Mudstone and limestone  | RAH-31-47   | 2.5              | 1.6                         | --        | --        | --               | 66.6                        | 83.78                                     |
| U-18                                       | Mudstone, calcareous  | LES-46-47   | 2.6              | 2.8                         | --        | --        | --               | 67.7                        | 78.78                                     |
| U-17                                       | Mudstone, calcareous  | LES-34-47   | 1.0              | 3.4                         | --        | --        | --               | 52.4                        | 95.06                                     |
| U-16                                       | Mudstone, calcareous  | LES-33-47   | 2.4              | 2.3                         | --        | --        | --               | 61.7                        | 24.6                                      |
| U-15                                       | Mudstone, calcareous  | LES-32-47   | 1.0              | 3.3                         | --        | --        | --               | 65.2                        | 25.6                                      |
| U-14                                       | Mudstone, calcareous  | LES-31-47   | 1.5              | 2.9                         | --        | --        | --               | 65.8                        | 27.1                                      |
| U-13                                       | Mudstone, calcareous  | Phosphate rock and calcareous mudstone containing chert | 1.5              | 6.7                         | --        | --        | --               | 61.1                        | 28.6                                      |
| U-12                                       | Mudstone, calcareous  | LES-30-47   | 1.05             | 3.3                         | --        | --        | --               | 72.1                        | 29.65                                     |
| U-11                                       | Mudstone, calcareous  | LES-29-47   | 1.4              | 3.2                         | --        | --        | --               | 70.2                        | 31.05                                     |
| U-10                                       | Mudstone, calcareous  | LES-28-47   | 2.4              | 3.8                         | --        | --        | --               | 66.6                        | 33.45                                     |
| U- 9                                       | Mudstone, calcareous  | LES-27-47   | 2.5              | 3.4                         | --        | --        | --               | 73.9                        | 35.95                                     |
| U- 8                                       | Mudstone, calcareous  | LES-26-47   | 0.65             | 8.7                         | --        | --        | --               | 34.7                        | 147.24                                    |
| U- 7                                       | Limestone, argillaceous, phosphatic   | LES-25-47   | 3.4              | 5.7                         | --        | --        | --               | 62.6                        | 152.90                                    |
| U- 6                                       | Mudstone, calcareous  | LES-24-47   | --               | --                          | --        | --        | --               | 40.00                       | 172.28                                    |

|  |  |            |      |      |    |    |      |       |        |
|--|--|------------|------|------|----|----|------|-------|--------|
| U- 5                                     | Phosphate rock, argillaceous                                 | LES- 23-47 | 0.55 | 23.1 | -- | -- | 24.8 | 40.55 | 184.98 |
| U- 4                                     | Limestone, argillaceous                                      | LES- 22-47 | 1.45 | 5.9  | -- | -- | 41.8 | 42.00 | 193.54 |
| U- 3                                     | Mudstone, calcareous   | LES- 21-47 | 5.0  | 1.8  | -- | -- | 56.8 | 47.00 | 202.54 |
| U- 2                                     | Mudstone, calcareous   | LES- 20-47 | 1.9  | 2.2  | -- | -- | 65.0 | 48.90 | 206.72 |
| U- 1                                     | Phosphate rock, argillaceous; fos. col. no. 47-HW-29         | LES- 19-47 | 0.6  | 25.1 | -- | -- | 22.3 | 49.50 | 221.78 |
| Rex chert member of Phosphoria formation |  |            |      |      |    |    |      |       |        |
| R-26                                     | Limestone, phosphatic; fos. col. no. 47-HW-2B                | LES- 18-47 | 0.3  | 11.4 | -- | -- | 10.0 | 0.3   | 3.42   |
| R-25                                     | Limestone; fos. col. no. 47-HW-33                            | --         | 3.5  | --   | -- | -- | --   | 3.8   | --     |
| R-24                                     | Limestone, phosphatic  | --         | 0.3  | --   | -- | -- | --   | 4.1   | --     |
| R-23                                     | Limestone, contains chert; fos. col. no. 47-HW-36            | --         | 5.0  | --   | -- | -- | --   | 9.1   | --     |
| R-22                                     | Limestone, phosphatic  | --         | 2.3  | --   | -- | -- | --   | 11.4  | --     |
| R-21                                     | Limestone, cherty; fos. col. no. 47-HW-37                    | --         | 5.1  | --   | -- | -- | --   | --    | --     |
| R-20                                     | Limestone and chert; fos. col. no. 47-HW-38                  | --         | 9.0  | --   | -- | -- | --   | 16.5  | --     |
| R-19                                     | Limestone  | --         | 2.0  | --   | -- | -- | --   | 25.5  | --     |
| R-18                                     | Limestone and chert; fos. col. nos. 47-HW-39 and 47-HW-40    | --         | 8.0  | --   | -- | -- | --   | 27.5  | --     |
| R-17                                     | Limestone; fos. col. no. 47-HW-27                            | --         | 5.4  | --   | -- | -- | --   | 35.5  | --     |
| R-16                                     | Limestone; fos. col. no. 47-HW-26                            | --         | 5.4  | --   | -- | -- | --   | 40.9  | --     |
| R-15                                     | Limestone; fos. col. no. 47-HW-25                            | --         | 2.5  | --   | -- | -- | --   | 46.3  | --     |
| R-14                                     | Covered interval, probably fossiliferous limestone and chert | --         | 23.0 | --   | -- | -- | --   | 48.8  | --     |
| R-13                                     | Limestone; fos. col. nos. 47-HW-23 and 47-HW-24              | --         | 11.0 | --   | -- | -- | --   | 71.8  | --     |
| R-12                                     | Limestone and chert  | --         | 15.0 | --   | -- | -- | --   | 82.8  | --     |
| R-11                                     | Limestone  | --         | 4.5  | --   | -- | -- | --   | 97.8  | --     |
| R-10                                     | Limestone and chert  | --         | 7.5  | --   | -- | -- | --   | 102.3 | --     |
| R- 9                                     | Limestone and chert  | --         | 6.2  | --   | -- | -- | --   | 109.8 | --     |
| R- 8                                     | Mudstone, calcareous   | --         | 2.5  | --   | -- | -- | --   | 116.0 | --     |
| R- 7                                     | Mudstone, calcareous   | --         | 5.0  | --   | -- | -- | --   | 118.5 | --     |
| R- 6                                     | Mudstone, calcareous   | --         | 5.0  | --   | -- | -- | --   | 123.5 | --     |
| R- 5                                     | Mudstone, calcareous   | --         | 5.0  | --   | -- | -- | --   | 128.5 | --     |
| R- 4                                     | Mudstone, calcareous   | --         | 4.0  | --   | -- | -- | --   | 133.5 | --     |
| R- 3                                     | Chert and mudstone   | --         | 2.6  | --   | -- | -- | --   | 137.5 | --     |
| R- 2                                     | Quartzite, phosphatic  | --         | 1.2  | --   | -- | -- | --   | 140.1 | --     |
| R- 1                                     | Mudstone, dolomitic  | --         | 5.0  | --   | -- | -- | --   | 141.3 | --     |
|  |  |            |      |      |    |    |      |       | 146.3  |

<sup>1</sup> Fossil collection made by H. Wedow, Paleontology and Stratigraphy Branch, U. S. Geological Survey.

| Bed no.   | Rock description                       | Sample no. | Thickness (feet) | Chemical analyses (percent)   |                                |                                |                  | Cumulative thickness (feet) | Thickness <sup>x</sup> percent P <sub>2</sub> O <sub>5</sub> (cumulative <sup>y</sup> ) |
|---|--|------------|------------------|-------------------------------|--------------------------------|--------------------------------|------------------|-----------------------------|---|
|   |  |            |                  | P <sub>2</sub> O <sub>5</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | Loss on ignition | Acid insoluble              |   |
| Phosphatic shale member of Phosphoria formation |  |            |                  |                               |                                |                                |                  |                             |   |
| P-73  | Mudstone, calcareous                   | LES- 11-47 | 4.0              | 0.98                          | --                             | --                             | --               | 63.19                       | 4.0   |
| P-72  | Mudstone, phosphatic, calcareous       | LES- 12-47 | 2.0              | 10.63                         | --                             | --                             | --               | 48.2                        | 3.92  |
| P-71  | Mudstone, calcareous                   | LES- 13-47 | 4.2              | 1.0                           | --                             | --                             | --               | 49.6                        | 25.18   |
| P-70  | Phosphate rock, cherty                 | LES- 14-47 | 0.7              | 23.8                          | --                             | --                             | --               | 26.0                        | 29.38   |
| P-69  | Limestone, argillaceous                | LES- 15-47 | 2.8              | 1.8                           | --                             | --                             | --               | 42.5                        | 46.04   |
| P-68  | Mudstone, calcareous                   | LES- 16-47 | 1.7              | 1.2                           | --                             | --                             | --               | 73.6                        | 51.08   |
| P-67  | Mudstone and argillaceous limestone    | LES- 17-47 | 1.5              | 5.3                           | --                             | --                             | --               | 29.3                        | 53.12   |
| P-66  | Phosphate rock                         | LES- 35-47 | 1.3              | 33.5                          | 0.7                            | 0.55                           | 5.00             | 3.1                         | 61.07   |
| P-65  | Phosphate rock                         | LES- 36-47 | 0.7              | 34.9                          | 0.8                            | 0.65                           | 2.98             | 4.1                         | 104.62  |
| P-64  | Phosphate rock                         | LES- 37-47 | 1.0              | 32.6                          | 1.2                            | 0.85                           | 3.88             | 6.4                         | 129.05  |
| P-63  | Mudstone and phosphate rock            | LES- 38-47 | 0.4              | 8.2                           | --                             | --                             | --               | 60.0                        | 15.4  |
| P-62  | Limestone, argillaceous                | LES- 39-47 | 1.2              | 0.6                           | --                             | --                             | --               | 47.5                        | 20.3  |
| P-61  | Phosphate rock                         | LES- 40-47 | 0.9              | 32.0                          | --                             | --                             | --               | 6.6                         | 165.65  |
| P-60  | Phosphate rock, argillaceous           | LES- 41-47 | 2.0              | 26.2                          | --                             | --                             | --               | 24.2                        | 194.45  |
| P-59  | Phosphate rock; fos. col. no. 47-HW-22 | LES- 42-47 | 1.5              | 25.8                          | --                             | --                             | --               | 15.5                        | 246.85  |
| P-58  | Mudstone, calcareous                   | LES- 43-47 | 2.3              | 1.4                           | --                             | --                             | --               | 57.6                        | 285.55  |
| P-57  | Phosphate rock, argillaceous           | LES- 44-47 | 0.4              | 25.8                          | --                             | --                             | --               | 21.7                        | 288.77  |
| P-56  | Mudstone, calcareous                   | LES- 45-47 | 2.8              | 0.6                           | --                             | --                             | --               | 74.9                        | 299.09  |
| P-55  | Phosphate rock                         | LES- 59-47 | 0.4              | 28.8                          | --                             | --                             | --               | 10.2                        | 300.77  |
| P-54  | Limestone, argillaceous                | LES- 60-47 | 0.5              | 1.3                           | --                             | --                             | --               | 42.4                        | 312.29  |
| P-53  | Phosphate rock, argillaceous           | LES- 61-47 | 0.35             | 22.6                          | --                             | --                             | --               | 27.6                        | 312.94  |
| P-52  | Limestone, argillaceous                | LES- 62-47 | 1.4              | 0.6                           | --                             | --                             | --               | 47.1                        | 320.85  |
| P-51  | Phosphate rock                         | LES- 63-47 | 0.6              | 23.5                          | --                             | --                             | --               | 19.1                        | 321.69  |
| P-50  | Phosphate rock, argillaceous           | LES- 64-47 | 0.6              | 16.8                          | --                             | --                             | --               | 34.6                        | 335.79  |
| P-49  | Phosphate rock, argillaceous           | LES- 65-47 | 0.6              | 14.6                          | --                             | --                             | --               | 36.3                        | 345.87  |
| P-48  | Limestone, argillaceous                | LES- 66-47 | 3.5              | 0.8                           | --                             | --                             | --               | 42.7                        | 354.63  |
| P-47  | Mudstone                               | FCA- 15-47 | 0.45             | 4.4                           | --                             | --                             | --               | 55.3                        | 357.43  |
| P-46  | Phosphate rock, argillaceous           | FCA- 16-47 | 0.4              | 21.7                          | --                             | --                             | --               | 22.8                        | 359.41  |
| P-45  | Mudstone                               | LES- 68-47 | 0.45             | 0.2                           | --                             | --                             | --               | 61.5                        | 40.20   |
| P-44  | Mudstone                               | FCA- 17-47 | 0.5              | 0.1                           | --                             | --                             | --               | 66.7                        | 40.65   |
| P-43  | Mudstone                               | FCA- 18-47 | 0.65             | 0.4                           | --                             | --                             | --               | 73.6                        | 43.45   |
| P-42  | Mudstone                               | FCA- 19-47 | 0.5              | 3.2                           | --                             | --                             | --               | 67.6                        | 42.50   |
| P-41  | Mudstone                               | FCA- 20-47 | 0.35             | 6.4                           | --                             | --                             | --               | 55.3                        | 42.65   |
| P-40  | Dolomite                               | FCA- 1-47  | 0.8              | 0.5                           | --                             | --                             | --               | 7.6                         | 43.45   |
| P-39  | Mudstone, calcareous                   | FCA- 2-47  | 1.05             | 2.7                           | --                             | --                             | --               | 49.5                        | 372.73  |
| P-38  | Mudstone                               | FCA- 3-47  | 0.6              | 2.2                           | --                             | --                             | --               | 80.8                        | 375.56  |
| P-37  | Mudstone, phosphatic                   | FCA- 4-47  | 0.6              | 13.0                          | --                             | --                             | --               | 43.4                        | 368.49  |
| P-36  | Limestone, argillaceous                | FCA- 5-47  | 2.3              | 0.4                           | --                             | --                             | --               | 42.4                        | 370.09  |
| P-35  | Mudstone, calcareous                   | FCA- 6-47  | 1.8              | 0.9                           | --                             | --                             | --               | 48.0                        | 372.33  |
| P-34  | Mudstone, phosphatic                   | FCA- 7-47  | 2.05             | 10.4                          | --                             | --                             | --               | 53.6                        | 385.60  |
|   |  |            |                  |                               |                                |                                |                  | 49.5                        | 387.22  |
|   |  |            |                  |                               |                                |                                |                  | 51.85                       | 408.54  |



SPECTROGRAPHIC ANALYSES—MIDDLE FORK OF PINE CREEK, WYOMING. LOT NO. 1205.

Semi-quantitative analyses of a few samples of the Phosphoria formation, Middle Fork of Pine Creek, Wyoming (see immediately preceding pages for location of section, thickness and description of strata, and chemical analyses of samples), made by U. S. Geological Survey Laboratory, Geochemistry and Petrology Branch, Washington, D. C. In addition to the elements listed in the table below, Be, Bi, Ce, Cs, Co, Cb, Ge, In, Hg, Mo, Nd, Pt, Re, Rb, Sc, Ta, Ti, Th, and W were looked for in all samples but were not detected.

Explanation of symbols

|                          |                             |
|--------------------------|-----------------------------|
| A = more than 10 percent | F = 0.001-0.01 percent      |
| B' = 1-10 percent        | G = less than 0.001 percent |
| D = 0.1-1 percent        | ND = not detected           |
| E = 0.01-0.1 percent     |                             |

| Bed no. | Sample no. | Al | Ba | B  | Cd | Ca | Cr | Cu | Fe | La | Pb | Mg | Mn | Ni | P  | Si | Ag | Na | Sr | Sn | Ti | V | Y | Zn | Zr |
|---------|------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|----|----|
| P-66    | LES-35-47  | D  | F  | F  | A  | D  | F  | D  | E  | E  | D  | F  | F  | A  | B' | G  | D  | F  | E  | E  | F  | E |   |    |    |
| P-65    | LES-36-47  | D  | F  | F  | ND | A  | D  | F  | D  | E  | E  | D  | F  | A  | B' | G  | D  | F  | E  | E  | F  | E |   |    |    |
| P-64    | LES-37-47  | D  | F  | ND | ND | A  | D  | F  | D  | E  | E  | D  | F  | A  | B' | G  | D  | D  | F  | E  | ND | E | F | E  |    |

<sup>1</sup> B' is equivalent to B and C of Bureau of Mines analyses.

LEEEFE, WYOMING. LOT NO. 1213.

Part of phosphatic shale member of Phosphoria formation sampled at two places in Leefe open pit mine of San Francisco Chemical Company 4 miles west of Sage, secs. 10 and 15, T. 21 N., R. 120 W., Uinta County, Wyoming. Beds are flat lying. Section of beds P-1 to P-11 from locality A measured and sampled by R. M. Campbell in December 1947; section of beds P-1 to P-23 from locality B measured by F. W. O'Malley and R. A. Harris and sampled by Harris and R. A. Smart in October 1948. Samples analyzed for  $P_2O_5$  and acid insoluble by U. S. Bureau of Mines Laboratory, Albany, Oregon, and for other constituents by Trace Elements Section Laboratory, U. S. Geological Survey, Washington, D. C.

| Bed no.   | Rock description                           | Sample no.  | Thickness (feet) | Chemical analyses (percent) |           |           |                  | Cumulative thickness (feet) | Thickness $\times$ percent $P_2O_5$ (cumulative) |  |  |  |  |  |
|---|--|-------------|------------------|-----------------------------|-----------|-----------|------------------|-----------------------------|--|--|--|--|--|--|
|   |  |             |                  | $P_2O_5$                    | $Al_2O_3$ | $Fe_2O_3$ | Loss on ignition |                             |  |  |  |  |  |  |
| Locality A <sup>1</sup>   |  |             |                  |                             |           |           |                  |                             |  |  |  |  |  |  |
| Phosphatic shale member of Phosphoria formation—partial section |  |             |                  |                             |           |           |                  |                             |  |  |  |  |  |  |
| P-11  | Phosphate rock, argillaceous               | RMC- 145-47 | 2.5              | 17.4                        | 2.1       | 1.67      | 9.14             | 31.6                        | 2.5  |  |  |  |  |  |
| P-10  | Limestone, argillaceous                    | RMC- 144-47 | 0.7              | 1.7                         | 3.6       | 1.65      | 28.26            | 29.2                        | 3.2  |  |  |  |  |  |
| P- 9  | Phosphate rock                             | RMC- 143-47 | 2.7              | 35.5                        | 0.66      | 0.53      | 3.50             | 3.1                         | 5.9  |  |  |  |  |  |
| P- 8  | Phosphate rock, argillaceous               | RMC- 142-47 | 0.4              | 26.9                        | 3.4       | 0.80      | 3.94             | 20.7                        | 6.3  |  |  |  |  |  |
| P- 7  | Phosphate rock                             | RMC- 141-47 | 1.0              | 34.6                        | 0.99      | 0.61      | 3.12             | 4.2                         | 7.3  |  |  |  |  |  |
| P- 6  | Phosphate rock                             | RMC- 140-47 | 0.9              | 32.6                        | 1.2       | 2.10      | 4.00             | 5.4                         | 8.2  |  |  |  |  |  |
| P- 5  | Phosphate rock, argillaceous               | RMC- 139-47 | 0.6              | 20.8                        | 5.5       | 1.00      | 4.22             | 33.5                        | 8.8  |  |  |  |  |  |
| P- 4  | Phosphate rock, argillaceous               | RMC- 138-47 | 1.4              | 28.8                        | 2.6       | 0.82      | 3.74             | 14.5                        | 10.2   |  |  |  |  |  |
| P- 3  | Phosphate rock, argillaceous               | RMC- 137-47 | 1.2              | 28.8                        | 2.9       | 0.69      | 3.82             | 18.3                        | 11.4   |  |  |  |  |  |
| P- 2  | Phosphate rock, argillaceous               | RMC- 136-47 | 0.8              | 24.8                        | 3.6       | 1.46      | 3.80             | 26.3                        | 12.2   |  |  |  |  |  |
| P- 1  | Phosphate rock, argillaceous               | RMC- 135-47 | 0.3              | 23.0                        | 4.8       | 0.79      | 2.84             | 32.7                        | 12.5   |  |  |  |  |  |
|   |  |             |                  |                             |           |           |                  |                             | 329.34   |  |  |  |  |  |
| Locality B  |  |             |                  |                             |           |           |                  |                             |  |  |  |  |  |  |
| Phosphatic shale member of Phosphoria formation—upper part only |  |             |                  |                             |           |           |                  |                             |  |  |  |  |  |  |
| P-24  | Chert                                      | --          | 0.03             | --                          | --        | --        | --               | --                          | --   |  |  |  |  |  |
|   | Bed P-24 may represent base of Rex member. |             |                  |                             |           |           |                  |                             |  |  |  |  |  |  |
| P-23  | Mudstone, cherly                           | RH-3326     | 2.0              | 3.5                         | --        | --        | --               | 83.9                        | 2.0  |  |  |  |  |  |
| P-22  | Phosphate rock, argillaceous               | RH-3325     | 0.8              | 23.9                        | --        | --        | --               | 30.9                        | 2.8  |  |  |  |  |  |
| P-21  | Mudstone                                   | RH-3324     | 1.3              | 2.9                         | --        | --        | --               | 79.9                        | 4.1  |  |  |  |  |  |
| P-20  | Phosphate rock, argillaceous               | RH-3323     | 0.4              | 28.5                        | --        | --        | --               | 20.8                        | 4.5  |  |  |  |  |  |
| P-19  | Mudstone                                   | WOM - 3322  | 1.7              | 3.6                         | --        | --        | --               | 72.4                        | 6.2  |  |  |  |  |  |
| P-18  | Mudstone, phosphatic and cherly            | WOM - 3321  | 1.0              | 18.3                        | --        | --        | --               | 44.2                        | 7.2  |  |  |  |  |  |
| P-17  | Phosphate rock                             | WOM - 3320  | 0.4              | 9.5                         | --        | --        | --               | 63.6                        | 7.6  |  |  |  |  |  |
| P-16  | Mudstone, phosphatic                       | WOM - 3319  | 0.8              | 21.4                        | --        | --        | --               | 34.0                        | 8.4  |  |  |  |  |  |
| P-15  | Phosphate rock and mudstone                | WOM - 3318  | 4.5              | 35.0                        | --        | --        | --               | 4.7                         | 12.9   |  |  |  |  |  |
| P-14  | Phosphate rock, calcareous                 | RH-3317     | 1.4              | 26.7                        | --        | --        | --               | 2.0                         | 14.3   |  |  |  |  |  |
|   |  |             |                  |                             |           |           |                  |                             | 281.51   |  |  |  |  |  |

<sup>1</sup> Beds P-1 to P-11 of locality A are probably equivalent to beds P-9 through P-18 of locality B.

| Bed no. | Rock description                         | Sample no. | Thickness (feet) | Chemical analyses (percent)   |                                |                                |                  | Cumulative thickness (feet) | Thickness x percent P <sub>2</sub> O <sub>5</sub> (cumulative) |
|---------|--|------------|------------------|-------------------------------|--------------------------------|--------------------------------|------------------|-----------------------------|--|
|         |  |            |                  | P <sub>2</sub> O <sub>5</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | Loss on ignition |                             |  |
| P-13    | Phosphate rock                           | RH-3316    | 0.8              | 34.1                          | --                             | --                             | --               | 6.2                         | 308.79   |
| P-12    | Phosphate rock                           | RH-3315    | 0.3              | 35.5                          | --                             | --                             | --               | 4.6                         | 319.44   |
| P-11    | Phosphate rock                           | WOM - 3314 | 0.8              | 27.0                          | --                             | --                             | --               | 19.3                        | 341.04   |
| P-10    | Phosphate rock                           | WOM - 3313 | 1.4              | 28.5                          | --                             | --                             | --               | 17.6                        | 380.94   |
| P- 9    | Phosphate rock, argillaceous             | WOM - 3312 | 0.6              | 17.7                          | --                             | --                             | --               | 43.2                        | 391.56   |
| P- 8    | Mudstone                                 | WOM - 3311 | 2.0              | 3.9                           | --                             | --                             | --               | 76.7                        | 399.36   |
| P- 7    | Phosphate rock                           | WOM - 3310 | 0.7              | 29.9                          | --                             | --                             | --               | 13.9                        | 420.29   |
| P- 6    | Phosphate rock                           | WOM - 3309 | 0.7              | 34.5                          | --                             | --                             | --               | 7.3                         | 444.44   |
| P- 5    | Phosphate rock, argillaceous             | WOM - 3308 | 1.5              | 19.5                          | --                             | --                             | --               | 37.3                        | 473.69   |
| P- 4    | Phosphate rock, argillaceous             | WOM - 3307 | 1.0              | 23.7                          | --                             | --                             | --               | 28.0                        | 497.39   |
| P- 3    | Phosphate rock                           | WOM - 3306 | 1.2              | 28.8                          | --                             | --                             | --               | 17.6                        | 531.95   |
| P- 2    | Mudstone and argillaceous phosphate rock | WOM - 3305 | 1.1              | 15.6                          | --                             | --                             | --               | 47.7                        | 549.11   |
| P- 1    | Phosphate rock, argillaceous             | WOM - 3335 | 1.1              | 23.9                          | --                             | --                             | --               | 28.1                        | 575.40   |

SPECTROGRAPHIC ANALYSES—LEEFE, WYOMING. LOT NO. 1213.

Locality A

Semi-quantitative analyses of samples of the Phosphoria formation, Lee<sup>1</sup>, Wyoming (see immediately preceding pages for location of section, thickness and description of strata, and chemical analyses of samples), made by the U. S. Geological Survey Laboratory, Geochemistry and Petrology Branch. In addition to the elements listed in the table below, Sb, As, Be, Bi, B, Ce, Cs, Cb, Ge, Hg, Mo, Nd, Pt, Re, Rb, Sc, Ta, Ti, Th, Sn, and W, were looked for in all samples but were not detected.

Explanation of symbols

|                          |                             |
|--------------------------|-----------------------------|
| A = more than 10 percent | F = 0.001-0.01 percent      |
| B' = 1-10 percent        | G = less than 0.001 percent |
| D = 0.1-1 percent        | ND = not detected           |
| E = 0.01-0.1 percent     |                             |

| Bed no. | Sample no. | A <sub>1</sub> | Ba | Cd | Ca | Cr | Co | Cu | Ga | In | Fe | La | Pb | Mg | Mn | Ni | P  | Si | Ag | Na | Sr | Ti | V | Yb | Zn | Zr |
|---------|------------|----------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|----|----|----|
| P-11    | RMC-145-47 | B'             | E  | ND | B' | F  | ND | F  | G  | D  | E  | ND | E  | D  | E  | B' | A  | G  | D  | D  | E  | E  | G | E  | F  |    |
| P-10    | RMC-144-47 | B'             | E  | F  | A  | F  | ND | F  | F  | ND | ND | ND | E  | D  | E  | D  | E  | E  | D  | G  | D  | E  | G | F  | F  |    |
| P- 9    | RMC-143-47 | D              | E  | ND | A  | E  | ND | F  | F  | E  | F  | E  | E  | E  | E  | A  | B' | G  | D  | D  | E  | D  | G | E  | E  |    |
| P- 8    | RMC-142-47 | B'             | E  | ND | A  | E  | ND | F  | F  | D  | E  | E  | E  | D  | E  | E  | A  | B' | G  | D  | D  | E  | D | G  | E  |    |
| P- 7    | RMC-141-47 | D              | E  | ND | A  | E  | ND | F  | F  | G  | D  | E  | E  | E  | E  | D  | E  | A  | B' | G  | D  | E  | D | G  | F  |    |
| P- 6    | RMC-140-47 | D              | E  | F  | A  | E  | F  | F  | G  | D  | E  | E  | D  | E  | E  | A  | B' | G  | D  | D  | E  | D  | G | E  | F  |    |
| P- 5    | RMC-139-47 | B'             | E  | ND | B' | E  | F  | F  | F  | G  | D  | F  | E  | E  | D  | E  | B' | A  | G  | D  | D  | E  | D | G  | E  |    |
| P- 4    | RMC-138-47 | B'             | E  | F  | A  | E  | F  | F  | F  | G  | D  | E  | E  | D  | E  | E  | A  | B' | G  | D  | D  | E  | D | G  | E  |    |
| P- 3    | RMC-137-47 | B'             | E  | F  | A  | E  | F  | F  | F  | G  | D  | E  | E  | D  | E  | E  | E  | A  | B' | G  | D  | D  | E | D  | G  |    |
| P- 2    | RMC-136-47 | B'             | E  | F  | A  | E  | F  | F  | F  | ND | D  | E  | E  | E  | E  | E  | E  | A  | A  | D  | D  | E  | D | G  | E  |    |
| P- 1    | RMC-135-47 | B'             | E  | ND | A  | E  | ND | F  | F  | ND | D  | F  | E  | E  | D  | E  | E  | A  | A  | G  | D  | D  | E | D  | G  |    |

<sup>1</sup> B' is equivalent to B and C of Bureau of Mines analyses.